ARCHIVES OF OTOLARYNGOLOGY

VOLUME 33 MAY 1941 NUMBER 5

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# COLLAPSE OF THE NARES

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Little attention has been directed to the action of the nares as a possible cause for the altered physiology of the nose and as a factor in producing secondary sinusitis, with its aftermath. Physiologists have placed little stress on the importance of the nares as an obstruction in the deviation of air currents. This has been brought to light by Proetz in his experimental work on animals.

The results of Proetz'[1] experiments with smoke demonstrated that the direction of air currents is determined by the shape and position of the nostril and the angle at which the inspired air impinges on the slope of the bridge of the nose. It also appeared that employing a head with thin and shrunken middle turbinates or one with an amputated middle turbinate did not materially alter either the inspiratory or the expiratory air currents. Introducing obstacles of any description on either the septal or the lateral wall produced the most pronounced change, in that the entire current was broken into eddies and whirls.

The nares can cause a mechanical obstruction to the normal inspiratory circuitous route of the air currents. This obstruction may be either functional or organic. Before attempting to describe these conditions, I suggest that one must keep in mind that there may be other pathologic conditions which will explain altered nasal physiology.

The factors that will give the rhinologist most concern are not the anatomic deformities, such as the deviated septum, or the definite pathologic changes in the nasal mucosa brought about by barometric changes, obscure allergic manifestations or irritating factors, such as dust and gas, or endocrine disturbances, like hypothyroidism and dyspituitarism. However, it is essential that these factors be completely ruled out before one definitely concludes that collapse of the nares is totally responsible for the pathologic changes underlying the altered nasal function. Cases of collapse of the nares may well be divided into two general classifications, namely, those in which the collapse is functional and those in which it is organic.

From the Manhattan Eye, Ear, and Throat Hospital.

1. Proetz, A.: Some Intimate Studies of Nasal Function, Ann. Otol., Rhin. & Laryng. **41**:125 (March) 1932.

FUNCTIONAL TYPE

This type has been adequately described by Lillie and Simonton[2] as alar collapse (fig. 1, *1*). "The patient breathes with the nose and not through the nose." The inspirations are short and quick. The ala of the nose rotates on a horizontal axis, the interior margin turning laterally with a definite medial motion at the level of the superior margin of the greater alar cartilage, or the entire ala is drawn medially. The efforts of the patient to draw air into the nose increase the degree of medial motion; long slowly drawn inspirations diminish the tendency to collapse.

Since there is nothing organically wrong with the nares or the nose in general, it would seem that the fault lies entirely with the patient, because he does not know how to breathe. It is essential, then, that corrective measures be instituted in that direction. Demonstrate to the patient the correct manner of breathing and then have him look into a

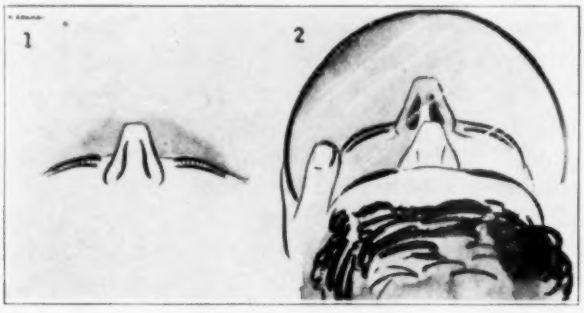


Fig. 1.—Functional collapse of the nares due to incorrect breathing (*1*). Patient looking into a mirror to observe the correct and the incorrect way of breathing (*2*).

mirror to see for himself the exact position of his nares when he is breathing correctly and when he is breathing incorrectly (fig. 1, *2*). In order to have the patient obtain the maximum amount of inspired air unimpeded, he is instructed to breathe in slowly, deeply and long with the nares intentionally dilated outwardly. This can be accomplished only after much patient exercise. The results in nasal hygiene are most gratifying.

ORGANIC COLLAPSE OF THE NARES MAY BE INCOMPLETE OR COMPLETE

*Incomplete Collapse of the Nares.*—Incomplete organic collapse is due to a weak or atrophic condition of the upper lateral cartilages. The cartilages spring from the upper border of the nasal septum, in the form of wings, and in a normal state are strong and resistant. They are attached laterally to the apertura piriformis by fibrous tissue.

2. Lillie, H. I., and Simonton, K. M.: Nasal Obstruction Caused by Collapse of Nasal Alae, Ann. Otol., Rhin. & Laryng. **48**:600 (Sept.) 1939.

These elastic and semirigid properties not only help to maintain the symmetry of the nose but also play an important part in the physiology of the nose by keeping the lateral wall (middle third) away from the medial wall during deep inspirations. When this support is lost, the increased intranasal pressure during inspiration produces a negative pressure, which influences the overactivity of the nasal muscles, brings about fatigue and thereby causes collapse of the middle third of the nose (fig. 2). Externally, the middle third of the nose is markedly concave during inspiration, and endonasally the area corresponding to the upper lateral cartilage can be seen to impinge on the septum. This condition causes a mechanical obstruction to the inspiratory stream of

Fig. 2.—The vertical black lines in the middle third of the lateral walls of the nares represent the areas in which there is weakness due to atrophy of the upper lateral cartilages.

air. It produces eddies and whirls, which in turn account for the improper aeration of the nose and sinuses and the disturbance of the physiology of the nose.

There is only one treatment for this mechanical obstruction, and that is restoration of the nose to its natural anatomic configuration. A proper segment of cartilage to supplant the weak or atrophic upper lateral cartilage will be sufficient to give it material support. This graft may be obtained from the ear, from the septum or even from the lateral crus of the alar cartilage if that is hypertrophied.

The selected segment of cartilage should be prepared in a manner to conform with the normal configuration of the nose and should be large enough to give proper support. The perichondrium is left intact.

A horizontal incision is made at the superior border of the lateral crus of the alar cartilage (fig. 3). Through this incision the external skin is separated with scissors from the nasal mucosa up to the osseous boundary. The prepared cartilage graft, with its attached perichondrium upwards, is now inserted into this bed. The incision in the mucosa is sutured with black silk. The graft is immobilized by placing two interrupted mattress sutures of black silk from the nasal mucosa and tying them externally. To prevent undue pressure on the skin, a small roll of gauze is inserted externally in the suture before it is tied. No other dressing is necessary. Five days later, the sutures are removed.

*Complete Collapse of the Nares.*—This condition is not infrequent and is due to the fact that not only the upper lateral cartilages but also the alar cartilages and the nasal muscles are atrophied. The lateral nasal

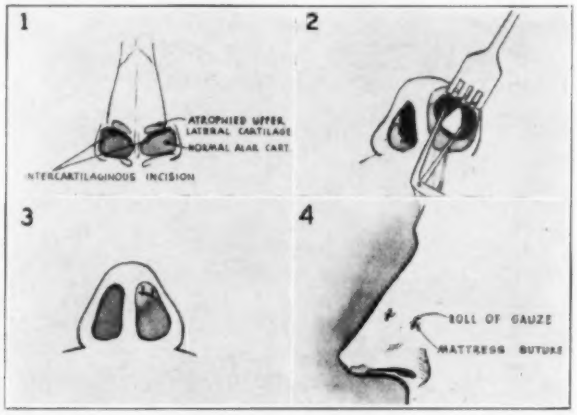


Fig. 3.—Intercartilaginous incisions (*1*). Insertion of cartilage graft with its attached perichondrium (*2*). Nasal mucosa sutured with black silk (*3*). Cartilage graft immobilized with two mattress sutures tied externally (*4*).

walls are atrophied, and the alterations in the physiology of the nose may be mild or marked. The nasal muscles are considered rudimentary by many anatomists and physiologists. However, I do not subscribe to this theory.

Facial and nasal muscles play an important role in our daily expression of life. This has been deeply studied and analyzed by the physiognomists, philosophers, characterologists and painters. Huber,[3] in 1931, made some historic notes on the researches in facial musculature and facial emotion.

It was Vesalius, in 1543, who for the first time gave some facial musculature to his figures. This was advanced somewhat by the works

3. Huber, E.: Zur Morphologie der Supraorbital- und Glabellarmuskulatur des Menschen, Anat. Anz. **62**:525, 1926.

of Eustachio. Henle, 1855 to 1858, in his textbook on human anatomy, attempted to view the facial muscle group from a genetic rather than from a merely descriptive aspect. Nevertheless, he had no deeper insight into the phylogeny of the facial musculature. It was Gegenbauer's phylogenetic considerations that gave the fundamental principle of using the muscle nerves as guides in the study of the morphologic differentiation of a given muscle group. This working method has become indispensable for comparative anatomic investigation of the muscle system.

Although attempts to analyze and explain man's facial expression are very old, the extensive literature on the "science of physiognomy," especially the older, is full of worthless statements and fantastic speculations. However, a series of publications on facial expression introduced by the classic works of Bell [4] and Darwin [5] is on a sound morphologic basis; yet hardly more than a beginning has been made in correlating facial expressions in neurophysiology.

Anatomy forms not only a science of great interest but one which will be sure to give the artist a true spirit of observation. It teaches him to perceive the essential in expression and to direct his attention to the effect and force as well as to the delicacy on which his delineation depends.

"Thus the painter must study the traits of human expression. Tranquillity or repose, in the strict sense of the words, can be truly represented only by one who can with equal facility depict energy of the features and figure, for in rest there must be character, and that character will best be expressed by him who has studied the effect of the actions of the muscles." [4]

With the aid of the writings of Cunningham,[6] Gray,[7] Piersol,[8] Sobotta [9] and Spalteholz,[10] several cadavers were used in an attempt to classify the nasal muscles under the same terms which are used for the classification of the muscles of the larynx: namely, dilators (abductors) and constrictors (adductors).

4. Bell, C.: The Anatomy and Philosophy of Expression as Connected with the Fine Arts, ed. 6, London, 1872.

5. Darwin, C.: The Expression of the Emotions in Man and Animals, London, 1872.

6. Cunningham, D. J.: Text-Book of Anatomy, ed. 4, New York, William Wood and Company, 1913.

7. Gray, H.: Anatomy of the Human Body, ed. 21, Philadelphia, Lea & Febiger, 1924, p. 380.

8. Piersol, G. A.: Human Anatomy, edited by G. C. Huber, ed. 9, Philadelphia, J. B. Lippincott Company, 1930, p. 486.

9. Sobotta, J.: Atlas and Test Book of Human Anatomy, Philadelphia, W. B. Saunders Company, 1908, p. 176.

10. Spalteholz, W.: Atlas of Human Anatomy, translated by L. F. Barker, Philadelphia, J. B. Lippincott Company, 1900-1903, vol. 2.

MUSCLES OF THE NOSE

*Quadratus Labii Superioris.*—The quadratus labii superioris is a triangular muscle and has three heads.

The angular head (levator labii superioris alaeque nasi) arises from the frontal process of the maxilla, fusing with the frontalis and the orbicularis oculi. As the muscle comes down, it splits into two definite and distinct portions, the inner one (alar portion), passing to the ala of the nose (levator alae nasi), which is a nasal dilator, and a stronger lateral portion, which fuses with the orbicularis oris. The latter portion raises the upper lip and helps in forming the nasolabial furrow, which passes from the side of the nose to the upper lip and gives to the face an expression of sadness.

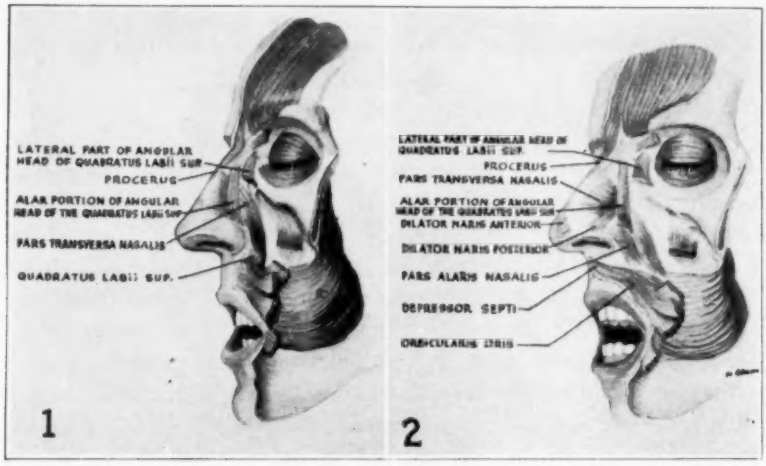


Fig. 4.—*1* shows the relation of the nasal muscles, with the lateral portion of the angular head of the quadratus labii superioris detached. *2* shows the relation of the deeper muscles of the nose to each other.

Innervation is supplied by the facial nerve.

The infraorbital and zygomatic heads are not nasal muscles but oral muscles, whose function is to raise the upper lip.

*Dilator Naris Anterior and Dilator Naris Posterior.*—The dilator naris anterior and the dilator naris posterior are two very small fasciculi. The anterior fasciculus arises from the alar cartilage to fuse with the skin near the margin of the nostril. The posterior fibers arise from the nasal notch of the maxilla and the sesamoid cartilages under the quadratus labii superioris to fuse with the skin near the margin of the nostril, just posterior to the anterior fasciculus.

These two fasciculi enlarge the aperture of the nares in ordinary breathing. In forced inspiration and marked emotional display they contract forcibly.

*Procerus (Pyramidalis Nasi).*—The procerus is a small muscle bundle arising from the lower part of the nasal bone and the upper part of the upper lateral cartilage to be inserted into the skin over the lower part of the forehead, between the two eyebrows. It draws down the medial angle of the eyebrow and produces transverse wrinkles over the bridge of the nose.

Innervation is supplied by the facial nerve.

*Nasalis.*—The nasalis is a thin flat muscle which arises from the maxilla above the incisive fossa and divides into two parts. One part, the pars alaris (depressor alae nasi), passes upward and medially to be inserted into the alar cartilage of the nose. The action is to draw the ala downward and inward, thereby constricting the lower third of the nares. The more lateral bundle, called the pars transversa (compressor narium), proceeds upward and medially under the angular head of the quadratus labii superioris and over the ala of the nose, to terminate on the dorsal surface of the nose in a thin aponeurosis, which unites with its fellow on the other side. The function of the compressor narium is to constrict the middle third of the nares.

Innervation is supplied by the facial nerve.

*Depressor Septi.*—The depressor septi (depressor alae nasi) arises from the incisive fossa of the maxilla; its fibers ascend to be inserted into the septum and the back part of the ala of the nose. It lies between the mucous membrane and the muscular structure of the lip. The action is to draw the ala of the nose and the septum downward, thereby constricting the aperture of the nares.

Innervation is supplied by the facial nerve.

### CONSTRICTORS AND DILATORS OF THE NOSE

| Dilators of the Nose | Constrictors of the Nose |
|---|---|
| 1. Medial, or alar, portion of the angular head of quadratus labii superioris | 1. Pars alaris nasalis |
| 2. Anterior dilator naris | 2. Pars transversa nasalis |
| 3. Posterior dilator naris | 3. Depressor septi |

### IMPORTANCE OF NASAL MUSCULATURE TO LIFE

The profile, form and muscles of the nose play an important role in denoting the character and personality. This fact has been emphasized by McCormick.[11] When the alae, or wings, of the nose are thin, shell-like, expanded, translucent and sharply cut in outline, cleverness and a

11. McCormick, L. H.: Characterology, Chicago, Rand-McNally & Company, 1920.

highly nervous organization are presaged; if they are contracted, thick and puffy, they support dulness of intellect. The nostrils of some persons vibrate continually in conversation, denoting choleric temperament, cleverness, sensitiveness, nervousness, independence, energy, resolution and high mentality.

The African Negro, the American Indian and the aborigines of Australia, habitants of wild and open countries, have large and expanded nostrils, revealing strength of heart and lungs and the capacity for running great distances without fatigue. Nostrils of this variety indicate keen scent, which is of vital necessity to savage tribes as a protection from the enemy and also as an aid in tracking their quarry. The broad, low-lying African nose has a markedly concave profile, which signifies weakness and lack of assertiveness and initiative. Its breadth signifies great physical endurance.

Narrow nostrils suggest petulance, nervousness and delicate health and are contrary to continuity, force and longevity.

Fig. 5.—Test to show whether operation will improve breathing.

Small, contracted noses, pinched nostrils, small mouths and narrow jaws are the result of indoor, sedentary living on the part of ancestors, from whom one involuntarily acquires one's physical inheritance. Large, broad, arched noses, large mouths and broad jaws are from forebears who led an outdoor existence and were accustomed to physical exertion.

## SURGICAL CONSIDERATIONS

The entire lateral wall of the completely collapsed nose is atrophied and weak. Any physiologic adjustment or implantation of cartilage would not be adequate. In order to prevent the lateral walls from impinging medially during inspiration, it is necessary to transfix these walls laterally in such a position that they cannot collapse. This operation, called the "lateral transfixation of the nares," has been fully described elsewhere (Cinelli [12]).

12. Cinelli, A. A.: Alterations in Nasal Function Due to Anatomic Variations of the Nares, Arch. Otolaryng. **31**:53 (Jan.) 1940.

Figure 5 shows the technic for testing patients with contracted nostrils to ascertain whether they are candidates for this type of surgical intervention or whether the underlying cause is some other pathologic condition. Insert a small thin wooden applicator in each nostril. Push the nares outward and upward, and if the patient experiences on inspiration a marked increase in the volume of air, one can safely predict that this operation will afford the same amount of relief. If the patient experiences no relief during inspiration when the nares are pushed outward, then one should look for other pathologic conditions.

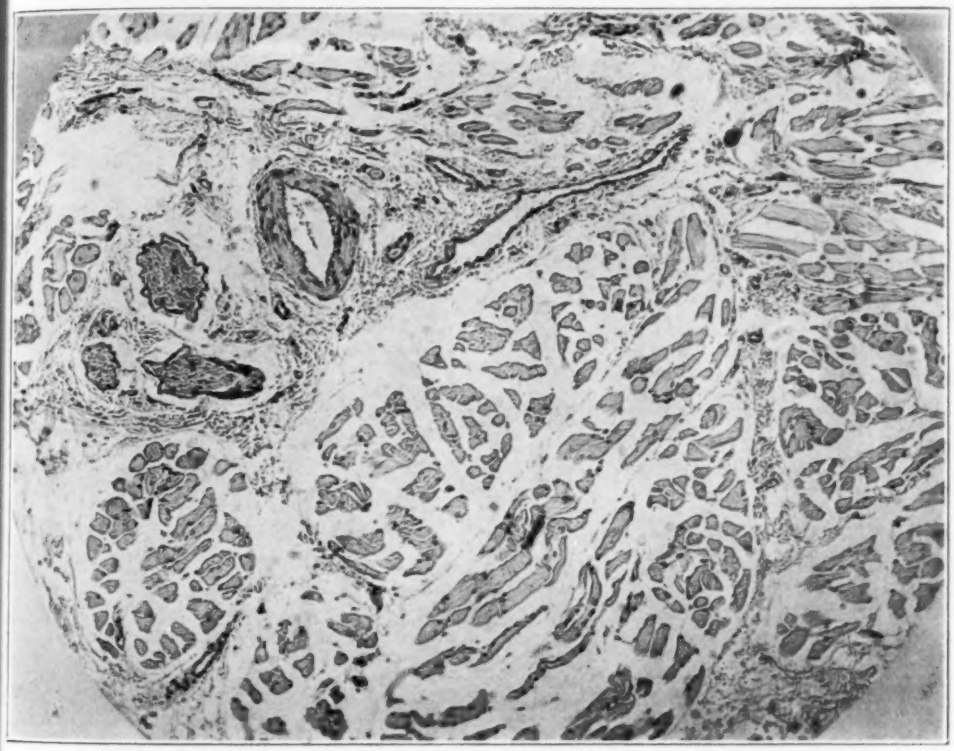

Fig. 6.—Cross section of normal nasal tissue, showing numerous bundles of striated muscle running in several directions, several nerves and blood vessels and some fat and fibrin tissue. The muscles appear well developed.

Figure 6 shows a cross section of the normal muscular tissue of the nose, whereas figure 7 shows a cross section of the nasal tissue in a typical case of complete collapse of the nares. There is complete atrophy of the muscular tissue.

Recently an attempt was made to correlate the results of clinical examination with bacteriologic findings. The entire nose was swabbed with sterile cotton applicators, inserted through a sterile nasal speculum,

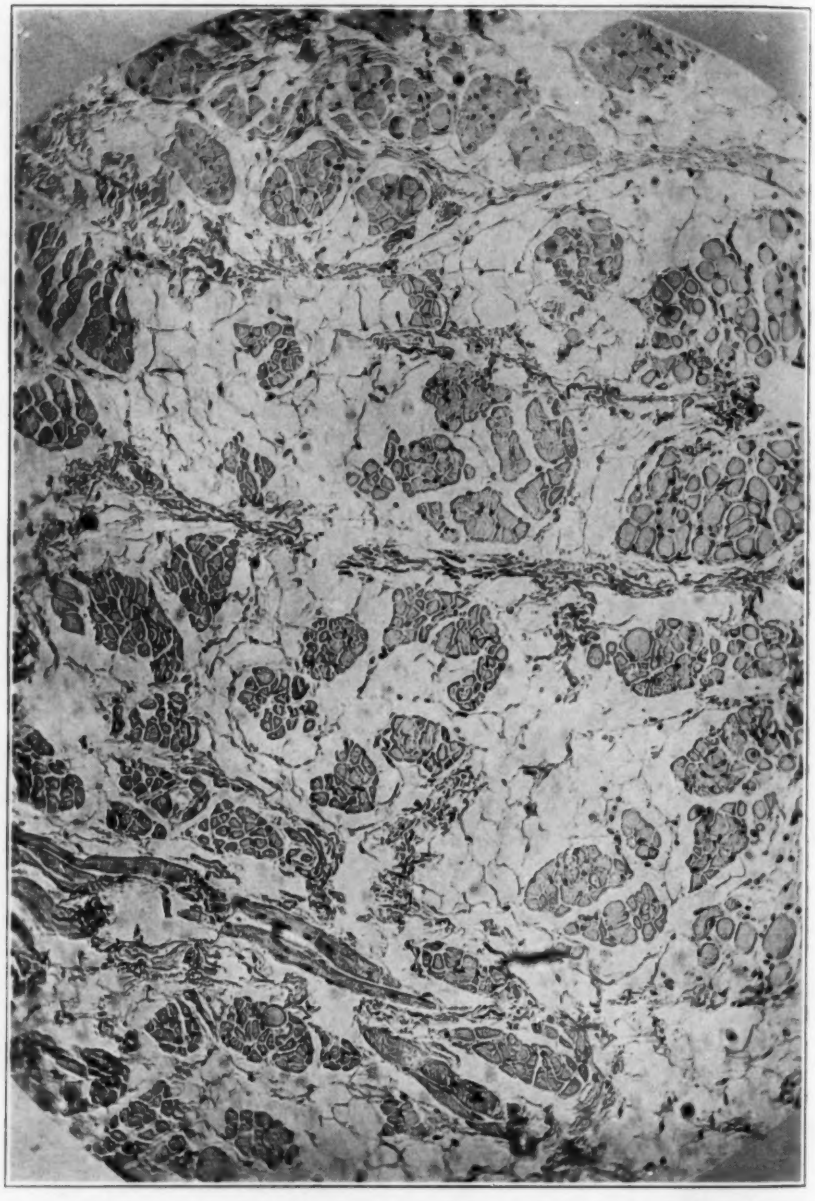

Fig. 7.—Cross section of nasal tissue, showing striated muscle tissue, fat and fibrous tissue. The muscle fibers appear atrophic. There are numerous nuclei; striations are preserved. The bundles are small and widely separated by fat and fibrous tissue.

and the material obtained was placed in blood agar plates and in broth, pour plate method, and incubated for forty-eight hours at 37 C. A study was made to determine the number of colonies and the type of predominating organisms that were found before operation and two months after the operation.

Thus far this study seems to indicate that there is a relationship between the clinical findings and the diminution in the number of colonies of infecting bacterial organisms that are found two months after surgical treatment. The series of 7 cases employed for the study is too small to give results of scientific value. However, it will be interesting to continue these experiments and at a later date to correlate the results for statistical study and possible further substantiation of our clinical results in the nasal hygiene of patients with collapse of the nares.

## SUMMARY

Collapse of the nares may be either functional or organic. In the functional type, the structural tissue of the nose is normal, but the patient does not breathe correctly. "He breathes with the nose and not through the nose." The proper corrective measure is to have the patient, before a mirror, breathe in slowly, deeply and long, with the nares intentionally dilated outwardly.

The organic type of collapse of the nares may be incomplete or complete. The incomplete collapse is due to a weakened or atrophic condition of the upper lateral cartilage. Correction is obtained by the implantation of cartilage with its attached outward perichondrium, which strengthens the middle third of the lateral wall, thereby giving sufficient mechanical support to prevent it from impinging toward the septum.

The complete organic collapse of the nares is due not only to atrophy of the upper lateral and alar cartilages but chiefly to atrophy of the dilator and constrictor muscles of the nares.

The nasal muscles play an important part in the physiology of the nose and in the physiognomy, character and personality; they are a source of emotional expression in the daily tasks and an understanding of their nature and function is of importance to persons engaged in the arts of painting and sculpturing. To consider these muscles rudimentary would be to destroy man's weapon of individuality.

The correction of complete organic collapse of the nares is surgical. The nares are transfixed laterally in such a position that they cannot collapse. The result is immediate improvement in breathing. A simple test is demonstrated to show whether this operation is indicated. Cross sections of nasal tissue, showing normal and atrophied muscles, are presented.

Mr. Joseph DiGemma made the sketches. Mr. James Weeks made the photographs.

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# OSTEOMYELITIS OF THE FRONTAL BONE

## REPORT OF THREE CLASSIFIED CASES

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Osteomyelitis of the frontal bone is one of the less common diseases seen by the otolaryngologist. However, every specialist in the field has an opportunity of encountering 1 or more cases, inasmuch as almost every patient with the complication is seen by several physicians. The condition was formerly thought to be due to surgical intervention in cases of frontal sinusitis. Such a complication does occur, but it is rare and in most instances seems to be the result of some predisposing factor in the patient's physical condition.

While the clinical signs and diagnosis are usually comparatively simple, the method of treatment is a matter of grave concern. I believe that the disease should be classified first, as soon as possible, and then treated according to its classification.

### HISTORY

Before the advent of antiseptics, osteomyelitis of the skull, like so many other diseases, flourished as the result of open injuries of the cranial bones. It was no wonder, then, that its principal source of origin, sinal or aural suppuration, escaped discovery until it was established by Tilley in 1897. However, as far back as 1760 Percival Pott demonstrated the association of pericranial abscesses and extradural abscesses. This striking feature is now referred to as Pott's puffy tumor.

In 1879 Lannelongue and von Bergmann substantiated Chassaignac's statement, made in 1859, that pericranial and extradural abscesses are due to osteomyelitis of the intervening bone.

One of the most comprehensive articles written on osteomyelitis of the frontal bone is that of McKenzie.[1] Previous to the publication of McKenzie's work Schilling [2] made a noteworthy contribution, and since

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Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society, Inc., June 1940.

1. McKenzie, D.: Diffuse Osteomyelitis from Nasal Sinus Suppuration, J. Laryng., Rhin. & Otol. **28**:6, 1913; Further Observations on Spreading Osteomyelitis of the Skull, ibid. **42**:293 (May) 1927.

2. Schilling, R.: Osteomyelitis of the Skull in Relation to Frontal Sinus and Middle Ear Complications, Ztschr. f. Ohrenh. **48**:152, 1904.

then outstanding work and papers have been presented by Bulson,[3] Furstenberg,[4] Wilensky,[5] Mosher and Judd,[6] Pastore and Williams,[7] Hill,[8] Adson and Hempstead,[9] Lewis [10] and Behrens.[11] Macewen [12] long ago pointed out that in most cases osteomyelitis of the frontal bone points to the orbit and that edema over the central portion of the frontal bone points toward infection of the longitudinal sinus.

## ANATOMY

It might be well here to review the anatomy of this portion of the skull as presented by Cunningham.[13] The frontal bone is the large shell of bone in the anterior part of the skull. Like other bones of the skull vault, the frontal bone has two tables of compact substance with a layer of diploe between them. The diploe is a layer of spongy substance, in which the marrow is largely replaced by venous blood. In each half of the frontal bone it disappears or is absorbed, leaving the frontal air sinuses situated immediately above the rim of the orbit and the root of the nose. Cunningham said:

> Diploic veins are anastomosing spaces in the diploe of the flat bones of the skull; they are lined with endothelium. The number of efferent vessels which emerge from the diploic spaces is not constant, but usually there are at least four on each side—a frontal, two parietal (anterior and posterior) and an occipital.
>
> The frontal diploic vein is one of the most constant; it drains the anterior part of the frontal bone, passes through a small aperture in the upper margin of the supra-orbital notch, and ends in the supra-orbital vein.

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3. Bulson, A. E., Jr.: Osteomyelitis of the Frontal Bone as a Complication of Frontal Sinusitis, J. A. M. A. **86**:246 (Jan. 23) 1926.

4. Furstenberg, A. C.: Osteomyelitis of the Skull: The Osteogenetic Processes in the Repair of Cranial Defects, Tr. Am. Laryng., Rhin. & Otol. Soc. **37**:1, 1931.

5. Wilensky, A. O.: Dakin's Solution in the Treatment of Osteomyelitis, Ann. Surg. **75**:708 (June) 1922; Osteomyelitis of the Skull Originating in the Temporal Bone, Arch. Otolaryng. **16**:160 (Aug.) 1932.

6. Mosher, H. P., and Judd, D. K.: An Analysis of Seven Cases of Osteomyelitis of the Frontal Bone Complicating Frontal Sinusitis, Laryngoscope **43**:153 (March) 1933.

7. Pastore, P. N., and Williams, H. L.: Osteomyelitis of Frontal Bone, Proc. Staff Meet., Mayo Clin. **13**:7 (Jan. 5) 1938.

8. Hill, F. T.: Osteomyelitis of the Skull, Arch. Otolaryng. **26**:9 (July) 1937.

9. Adson, A. W., and Hempstead, B. E.: Osteomyelitis of Frontal Bone, Arch. Otolaryng. **25**:363 (April) 1937.

10. Lewis, H.: Osteomyelitis of the Frontal Bone with Multiple Frontal Lobe Abscesses, J. Laryng. & Otol. **51**:107 (Feb.) 1936.

11. Behrens, H. C.: Osteomyelitis of the Skull of Otitic and Paranasal Sinus Origin, Arch. Otolaryng. **25**:272 (March) 1937.

12. Macewen, W.: Pyogenic Diseases of the Brain and Spinal Cord, Glasgow, James Maclehose & Sons, 1893.

13. Cunningham, D. J.: Text-Book of Anatomy, edited by J. C. Brash and E. B. Jamieson, ed. 7, New York, Oxford University Press, 1937.

The anterior parietal diploic vein drains the posterior part of the frontal bone and the anterior part of the parietal bone; . . .

The emissary veins convey blood from the venous sinuses of the dura mater to the veins which lie outside the walls of the cranium. They may be single veins, or plexiform channels surrounding other structures which are passing through the walls of the cranium; individual emissary veins vary greatly in size and are not always present. They frequently communicate with the diploic veins.

In the child, and sometimes in the adult, a frontal emissary vein passes from the anterior end of the superior saggital sinus through the foramen caecum. Its lower end divides into two channels, which either end in the veins of the frontal sinus or those of the roof of the nasal cavities, or they perforate the nasal bones and join the anterior facial veins.

## PATHOLOGIC CHANGES

Osteomyelitis of the skull is not necessarily confined in origin to injury or suppurating infection of the frontal sinus or the aural cavity. However, as McKenzie [1] pointed out, the proximity of the ethmoid sinuses to the meninges no doubt gives rise to conditions which result in meningitis and death before any disease of the bone may be detected. The same may be true of the sphenoid sinuses.

Some instances of osteomyelitis of the skull originating in the antrum have been reported, and this origin probably would be more common except that the infection is apt to be localized, and the difference in anatomic and vascular structure makes it possible to effect a comparatively easy cure.

There are differences of opinion regarding the method of spread of the infection, namely, by direct invasion of the osseous spaces or by primary infection of small efferent veins of the lining membrane of the sinus or by the veins to the bone. The last theory has the most support, in that thrombophlebitis of the diploic veins is generally found far in advance of the osseous infection. Von Eicken [14] has been doing a considerable amount of research in regard to the role played by the veins of the frontal bone in cases of osteomyelitis.

Infection by direct invasion is more common in frontal sinuses completely surrounded by compact bone than in these surrounded by diploe; this may be due to the meager supply of blood in the compact bone. The diffuse, spreading type of osteomyelitis seems to progress more rapidly when the diploe is abundant.

Williams and Heilman [15] described three clinical types of osteomyelitis of the frontal bone secondary to frontal sinusitis. These are:

1. The fulminating type, which usually follows swimming and is characterized by intense pain in the frontal region, generalized head-

14. Von Eicken, C.: Osteomyelitis of the Frontal Bone, Proc. Inter-State Post-Grad. M. Assemb. North America, 1938.

15. Williams, H. L., and Heilman, F. R.: Spreading Osteomyelitis of the Frontal Bone Secondary to Disease of the Frontal Sinus, Arch. Otolaryng. **25**: 196 (Feb.) 1937.

ache, high fever, rapidly spreading edema and a tendency to spread quickly to the arachnoid and cranial sinuses.

2. The localizing type, in which, after an initial advance, the process becomes completely isolated by reactive barriers, with eventual marginal sclerosis of bone.

3. The spreading type, in which the resistance is sufficient to prevent rapid advance but there is no tendency to complete localization.

## ETIOLOGY

McKenzie [1] pointed out that spontaneous osteomyelitis of the frontal bone is more common in cases of acute than in those of chronic sinusitis. Swimming, especially diving, usually in the presence of an acute infection of the upper respiratory tract, seems to be the most common etiologic factor. It is probable that some of the chemicals in swimming pools produce an added irritation. It has been suggested that the lead in the Missouri lead mine pools is a causative factor in that vicinity.

Whether or not osteomyelitis following surgical procedure on a frontal sinus would have occurred anyway is still a matter of controversy. In some instances the lapse of time between the operation and the appearance of the osseous infection creates doubt as to the causative factor. The veins may have been infected early, before the initial operative procedure. They become thrombosed and purulent, carrying the infection in their various directions until it collects and forms abscesses between the bone and the pericranium and between the bone and the dura mater, which, incidentally, is strongly resistant to infection. The next stage, of course, is extensive necrosis and osteomyelitis, due to obstruction of the blood supply.

In 1933 Ziegelman [16] wrote an article in which he stressed the importance of the emissary vein in cases of infection of the lateral sinus and of jugular thrombosis. This and other works along the same line seem to establish a definite relationship between the presence or absence of the emissary vein and the occurrence of spreading osteomyelitis. An emissary vein could be a direct factor in the spread of infection from a suppurating frontal sinus. There is an even chance that it plays an important role in the occurrence of osteomyelitis, and it may be responsible for the appearance of this disease in some persons and not in others, irrespective of the operative procedure.

It has been pointed out that osteomyelitis of the spontaneous variety is more frequently self-limiting than is that of the postoperative type. Here, again, the emissary vein may be a factor, although the bacterial organism or organisms present should, perhaps, be ranked first in the order of importance.

16. Ziegelman, E. F.: Surgical Importance of Mastoid Vein in Infected Lateral Sinus Thrombosis, Arch. Otolaryng. **18**:298 (Sept.) 1933.

### BACTERIOLOGY

Staphylococcus (albus and aureus) is the most common organism found in osteomyelitis, with Streptococcus and Pneumococcus next in order. One or all three may be present, according to Schilling [2] and Luc.[17]

It is my belief that a symbiosis of the organisms causes osteomyelitis of the fulminating type.

### REPORT OF CASES

CASE 1.—*Type 3.* T. W., a white boy aged 14, with a normal past history, was first seen by me on July 29, 1938. He gave a history of having been at a Boy Scout camp five weeks previously. At the camp he indulged in a great deal of diving sailor fashion, i. e., without the hands and arms upraised to protect the head. Also, in order to dive deeper, he held large rocks in his arms for added weight and momentum. Two weeks later he came home complaining of headache over the left eye with slight swelling of the eyelids and the left supraorbital region. In a few days the swelling receded but did not disappear. His sleep was disturbed and his appetite poor.

About the middle of July the swelling became larger and softer. On July 27 it was aspirated, and the parents were told that the patient had a low grade infection with hemolytic streptococcus. On the evening of July 28 he felt sufficiently well to attend a movie. The following morning he awakened with a feeling of confusion. This soon cleared up, and he was able to eat his breakfast, which he immediately vomited. About 9 a. m. he had an epileptiform seizure that lasted for several minutes. After this he vomited some mucoid material. He experienced another such attack on the way to the hospital, about 2 p. m., after which he again vomited. Shortly after reaching the hospital he had a generalized convulsion.

The child's parents, by the way, are Christian scientists.

*Examination.*—The pulse rate was 94, the respiration rate, 30 and the temperature 98.6 F. The eyelids of the left eye were swollen; the edema extended over the left frontal bone, with a large fluctuating mass present in the left temporal area, which was markedly tender. This area measured 8 by 5 cm. The outer table of the bone seemed to be eroded.

The neurologic examination revealed a slight degree of weakness of the right angle of the mouth and slight weakness of the grip of the right hand. When held extended, the right hand was definitely lower than the left. The response of the left foot to plantar stimulation was flexor in character, and that of the right was extensor. The patient was mentally confused. Babinski's sign was strongly positive on the right side during the last convulsion.

I was sure that the patient had an early right-sided hemiparesis with generalized convulsive attacks. Immediate drainage was felt to be advisable and in order.

*Roentgenographic Report.*—On July 29 roentgenographic study of the skull showed the left frontal bone to have a moth-eaten area measuring 5 cm. in diameter. It extended down to and possibly into the left frontal sinus, which was denser than the right.

The diagnosis was osteomyelitis of the left part of the frontal bone.

*Laboratory Findings.*—Urinalysis on July 29 gave negative results. Examination of the blood showed the hemoglobin content to be 91 per cent, the red blood cell

17. Luc, H.: L'ostéomyélite des os plats du crâne, Ann. d. mal. de l'oreille, du larynx, 1895, vol. 21, no. 5.

count 5,070,000, the color index 0.89 and the white blood cell count 11,500, with neutrophils 92 per cent, lymphocytes 4.5 per cent and monocytes 3.5 per cent.

*First Operation.*—An incision was made over the fluctuating mass in the left temple. When the periosteum was incised, a large amount of purulent fluid escaped. The bone under the periosteum was moth-eaten in appearance. A decompression was performed 1 inch (2.5 cm.) beyond the limit of the moth-eaten bone. No pus or other evidence of a gross pathologic condition was found in the bone at this site. On searching toward the midline, a fistula was found at the outer limit of the left frontal sinus. It extended to the dura mater, which appeared normal. A large area

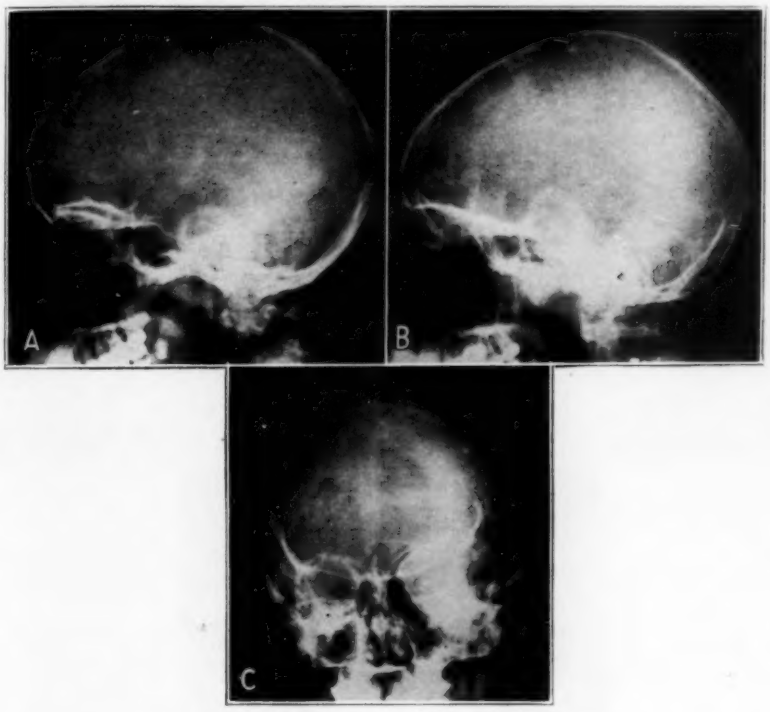


Fig. 1.—Type 3. Roentgenograms of the patient in case 1: *A*, lateral view, showing osteomyelitis of the anterior plate breaking through the posterior plate in several places; *B*, lateral view, showing extensive osteomyelitis of the outer plate of the frontal bone, and *C* anteroposterior view, showing osteomyelitis of practically the entire left side of the frontal bone.

was cleansed, and drainage was established with rubber drains. The purulent fluid was sent to the laboratory for culture.

When drainage had been established, the patient regained consciousness and stated that he felt well. At no time did his rectal temperature go over 100 F. Five days after operation the left upper eyelid was definitely edematous. This condition persisted. His eye movements were normal; the fundi were normal. He had no headache and was treated symptomatically.

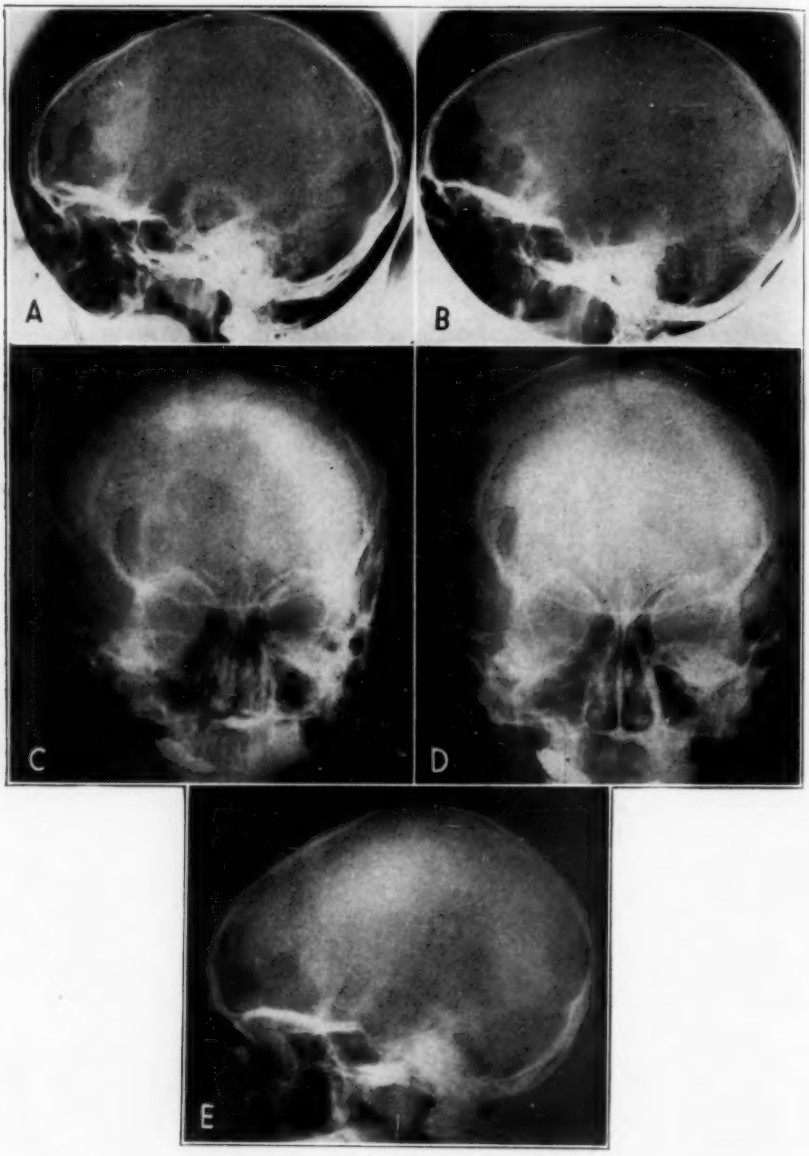


Fig. 2.—Type 3. Roentgenograms of the patient in case 1: *A*, lateral view, showing osteomyelitis of the outer plate. Extensive osteomyelitis of the inner plate and the button removed at the outer limit of the osteitis are visible. The process is beginning to sequestrate cleanly. *B*, a slightly more anterior view than *B*, showing the amount of the extension of the osteomyelitis. *C*, anteroposterior view after the removal of the sequestrums, showing the formation of new frontal bone. *D*, another anteroposterior view, showing the filling in of the button as well as the formation of new frontal bone. *E*, lateral view, taken several days after the removal of all of the osteomyelitic bone, showing the reformation of the anterior and posterior plate of the frontal bone.

*Postoperative Roentgenographic Report.*—Roentgenograms of the skull made on August 8, when compared with the original set, showed definite extension of the destructive process of the frontal bone. There was now seen in the left side apparently a dehiscence in the left frontal sinus. This appeared to lead downward to the orbit. The left frontal sinus was still more opaque than the right. The destructive process involved both tables of the left frontal bone over a limited area.

*Postoperative Laboratory Findings.*—A culture of the purulent fluid revealed Staphylococcus aureus.

The urine was normal.

The blood count on August 3 showed 8,300 white blood cells, with polymorphonuclears 70 per cent, lymphocytes 28 per cent and monocytes 2 per cent.

*Second Operation.*—The patient's condition did not improve, and, since the edema of the left upper eyelid was becoming more extensive, it was considered advisable to open the left supraorbital region.

On August 12 an incision was made in the left eyebrow and carried down toward the glabella. The periosteum was found to be dark red and bulging. When it was opened, a large amount of seropus and small fragments of bone escaped. The outer table of the frontal sinus was removed, as well as most of the inner table. The dura mater appeared normal. The nasofrontal duct was widely opened. Granulation tissue was removed from the previous wound, and a drainage tube was placed in the inner angle of the new wound and the lower portion of the old one.

*Postoperative Treatment and Course.*—The patient was returned to his room, and intravenous administration of sterile 5 per cent dextrose in physiologic solution of sodium chloride was instituted. His temperature remained almost normal, never going above 100 F. rectally. The swelling decreased gradually, and by August 23 the edema over the left upper eyelid had disappeared.

The neurologic examinations showed conditions gradually becoming normal, and the patient was dismissed.

*Postoperative Roentgenographic Report.*—Anteroposterior and left lateral stereoscopic roentgenograms of the skull made on September 19 when compared with the last previous roentgenograms, made on August 8, showed the same area of lessened density with, however, a definite increase of density and haziness in the diseased portions of the frontal bone. While approximately the same area was involved, there was definite evidence in the later roentgenograms which suggested healing, and the process was definitely not extended.

CASE 2.—*Type 2.* A. N., aged 29, a white single man, an actor, came to my office on June 1, 1935, stating that he had gone swimming two and a half years before while he was suffering from an acute cold. Immediately afterward an acute infection of the right ethmoid sinus and orbital cellulitis on the right side developed; this was further complicated by acute frontal sinusitis. At that time his physician punctured the right antrum, which was normal. Two days later he removed the right middle turbinate and uncapped some of the right ethmoid cells. Twenty-four hours later an incision was made in the eyebrow over the right frontal sinus for the placement of a rubber drain. About three weeks later the incision was reopened, and the sinus was drained again. Eleven months after the onset the patient had an intranasal opening of the right nasal frontal duct. Since his first operation, he had had a fistula present, which drained most of the time.

*Examination.*—The right upper eyelid showed moderate edema and induration, and a draining fistula. There were much scarring and a slight tenderness over the

frontal sinus. The fistula seemed to lead up into the floor of the frontal sinus; a probe could not be inserted through it into the sinus. The middle turbinate was gone; there was a large opening into the nasal frontal duct, and an enormous amount of pus was draining into the nose. The eye was directed downward and to the right; vision was entirely gone because of optic atrophy.

Roentgenograms showed a large amount of pus in the frontal sinus, with questionable osteomyelitis and sequestration.

The temperature was 99.8 F.

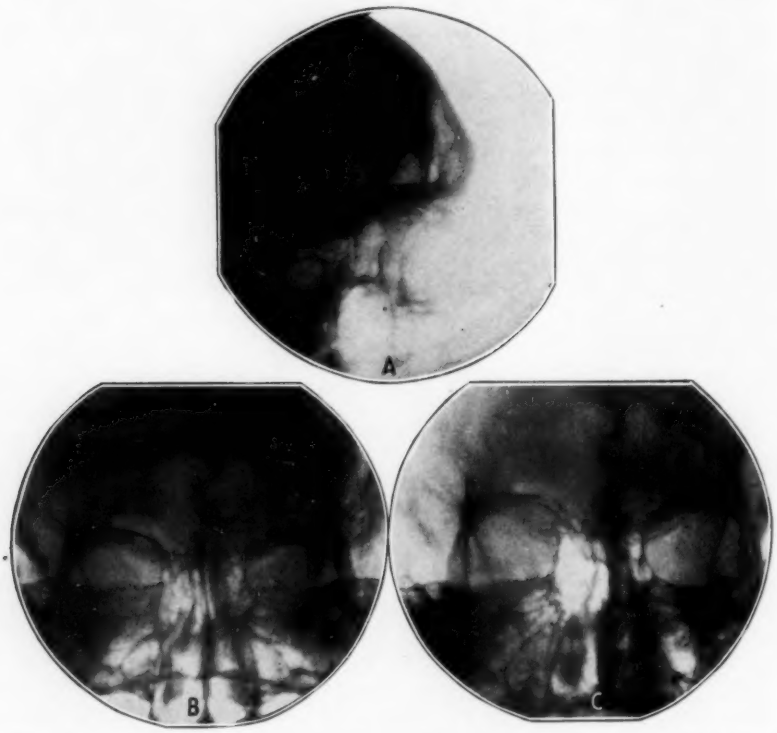


Fig. 3.—Type 2. Roentgenograms of the patient, case 2: *A*, lateral view, showing osteomyelitis of the anterior plate and questionable osteomyelitis of the posterior plate; *B*, anteroposterior view, showing osteomyelitis in the right part of the frontal bone (questionable sequestration of the posterior plate), and *C*, anteroposterior view, showing sequestrums of the posterior plate in the right part of the frontal bone.

*Laboratory Findings.*—The hemoglobin content of the blood was 79 per cent. The red blood cells numbered 3,940,000 and the white blood cells 8,500, with 7 per cent large monocytes, 61 per cent neutrophils and 32 per cent lymphocytes. The urine was normal with the exception of a few pus cells.

*Operation.*—Being an actor, the patient wished no deformity as a result of the operation. It was decided to open and explore the frontal sinus after the method of Coakley.

With the patient under general anesthesia induced by means of avertin with amylene hydrate, scopolamine hydrobromide and morphine sulfate, an incision was made through the old scar. The sinal tract was dissected out and found to enter the frontal sinus through an erosion in its floor. Also present was a small opening about 0.25 inch (0.64 cm.) in diameter, which had been made during the previous external operation. A considerable amount of pus gushed through this incision. After the opening was enlarged and the pus evacuated, two large sequestrums, 1.5 by 1.5 cm. and 2.5 by 1.5 cm., were found. They were large portions of the posterior sinal wall. A wide area of the frontal dura was exposed. The dura appeared normal. The edges of the posterior plate were clean, firm and hard. The membrane of the sinus, a mass of polypoid degeneration, was completely removed. The anterior plate was left intact.

A large tube was sutured in the enlarged frontal duct and brought out through the nostril.

Smears from the wound showed Staphylococcus aureus.

*Postoperative Course.*—The patient reacted well; his temperature did not go above 102 F. Two days after the operation there was a considerable amount of swelling in the right eye, which subsequently receded. The wound healed well, and the stitches were removed on the fourth day. The patient was discharged from the hospital on the fifth day, and the tube was removed through the nostril three weeks later.

He has remained well.

Case 3.—*Type 1.* P. T., aged 11, a white girl, was admitted to the hospital on Nov. 29, 1936, with a history of having had a cold for the past five days, which was getting worse.

*Examination.*—The patient was suffering from swelling over the left eye and in the frontal region, a temperature of 103 F. and convulsions.

Examination of the blood on the day of the patient's admission to the hospital showed the red blood cells to number 4,500,000 and the white blood cells 23,000, with neutrophils 84 per cent, lymphocytes 5 per cent and monocytes 11 per cent. The platelet count was normal.

The urine, throughout the course of the disease, showed epithelial cells, red blood cells and a few pus cells.

Roentgenograms made on November 30 showed an abnormal condition of the left maxillary antrum, the left frontal sinus and both ethmoids.

*Course and Preoperative Treatment.*—The child's condition became progressively worse. The left eye was fixed and proptosis marked. A tentative diagnosis of cavernous sinus thrombosis was made.

On December 1 she was given 500 cc. of blood by transfusion, and on December 7 the blood leukocyte count was 27,000, with 82 per cent polymorphonuclears. The leukocytes showed toxic changes.

On December 10 the glabellar region was aspirated and a large amount of fluid pus obtained, which when cultured showed Staphylococcus albus. At this time the patient had beginning cervical rigidity.

On December 13 an incision was made through the left eyebrow and about 70 cc. of pus was evacuated. The frontal bone was bare; there was no erosion. The following day the patient was much better and had no cervical rigidity or convulsions. Her temperature fell and remained lower for ten days. It then rose to 105 F. The examination of the blood showed 18,000 leukocytes, neutrophils 85 per cent, lymphocytes 11.5 per cent and monocytes 3 per cent.

Roentgenograms made on December 23 revealed destruction of the outline of the frontal sinus on both sides, more marked on the left. In the Granger view it appeared that the osteomyelitis had spread through the veins between the tables of the skull, upward and backward into the midportion of the frontal bone.

*Operation.*—The operative procedure decided on was a radical removal of all the infected bone.

The operation was performed on December 26. A hair line incision was marked off from temple to temple and completely outlined by interlocking stitches to prevent

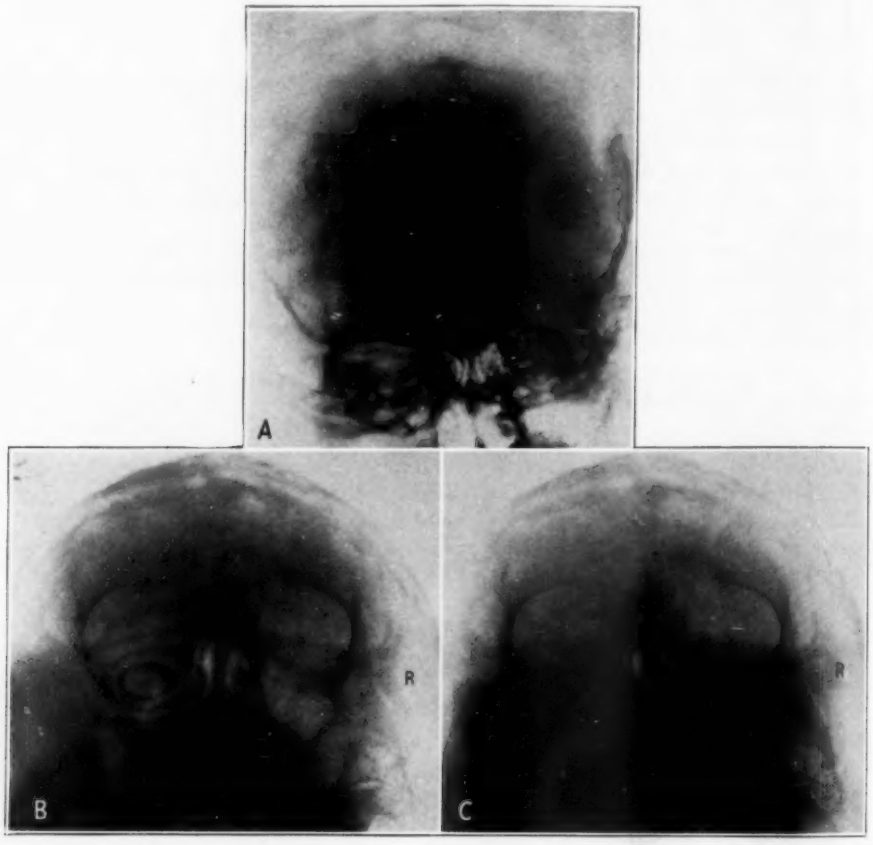


Fig. 4.—Type 1. Roentgenograms of the patient in case 3, showing: *A*, extensive osteomyelitis of practically the entire frontal bone (the process is extending into the diploe in all directions); *B*, the ragged external plate and the diploic extensions of the process, and *C*, extensive osteomyelitis of practically the entire frontal bone.

an unnecessary loss of blood. The initial incision was then made and the epidermis turned down over the forehead. The outer table was necrosed. The whole frontal bone and part of the parietal bone were removed. The diploe was filled with pus. The bone was removed back to healthy tissue. An extradural abscess, 1.5 inches

(4 cm.) in diameter, was found over the right frontal lobe. The dura here was thickened and covered with a purofibrinous exudate. The frontal sinuses were opened and the interfrontal septums removed. A Penrose drain was inserted, through which was placed a protruding 5 inch (13 cm.) trailer. The remainder of the trailer was covered with loose gauze, which had been soaked with peptone bouillon solution.

*Postoperative Course.*—The child improved rapidly and was dismissed from the hospital. The wound healed slowly but well. When the patient was last seen, in March, the frontal bone was definitely regenerating.

## COMMENT

It is interesting to note, in the type 3 case, that the button made 1 inch (2.5 cm.) past the moth-eaten bone revealed no evidence of infection. This established the diagnosis of a spontaneous spreading osteomyelitis that had localized.

The normal appearance of the dura would indicate that the osteomyelitis had spread by direct invasion and not by thrombophlebitis and the formation of epidural abscess.

The facts that the patient at no time had a high temperature and that the culture showed only Staphylococcus aureus seem correlated.

In the type 2 case the definite sequestrums, with the clean-appearing edges of the line and the absence of high fever, established the diagnosis.

The type 1 case is of note in that the diagnosis was difficult; the condition resembled cavernous sinus thrombosis. The early drainage established the diagnosis and classification. The procedure was clearly indicated and the results were gratifying.

The prevention of loss of blood by looping the stitches is a marked improvement over other methods and may be easily performed for small as well as large incisions of the scalp.

The question of the type of incision to be used in performing a radical operation for osteomyelitis of the frontal bone must necessarily be determined by the conditions present in the individual case. Morrison [18] suggested that if the inverted T incision is used, the horizontal incision be 0.5 inch (1.25 cm.) above the eyebrow, thus facilitating subsequent resort to plastic surgery.

In some instances, I believe, osteomyelitis may be prevented by instructing the patient to remain out of water, both pools and the ocean, while he is suffering from a cold. The middle meatus should be thoroughly shrunken during an acute cold or sinal attack by the use of cocaine and ephedrine solutions.

18. Morrison, L.: Osteomyelitis of the Frontal Bone: Report of Two Cases, read at the meeting of the California State Medical Association, Del Monte, Calif., 1938.

When pain is predominant in the frontal sinus, roentgen therapy should be tried, and if no relief is obtained, early external drainage through the lower portion of the frontal sinus should be established.

SUMMARY

Cases are presented of osteomyelitis of the frontal bone, as diagnosed and classified by Williams and Heilman.

The management of such cases is dependent on:

1. Drainage and the establishment of the classification.

2. Careful removal of all the infected bone.

3. Symptomatic treatment, including intravenous administration of dextrose solution, blood transfusion and the administration of sulfanilamide or one of its less toxic derivatives.

4. If the infection is due to a streptococcus of the hemolytic variety, human scarlet fever convalescent serum is of apparent value.

5. If the infection is due to one of the types of Pneumococcus, the corresponding type of pneumococcic serum should be used, with the possible addition of sulfapyridine (2-[paraaminobenzenesulfonamido]-pyridine).

# NITROGEN MONOXIDE AND OXYGEN FOR ANESTHETIZATION IN OPERATIONS FOR MALIGNANT GROWTHS OF THE LARYNX

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Since surgical procedures offer the best results in the treatment of malignant growths of the larynx, particularly those of the intrinsic type, some anesthetic must be employed. Of course when irradiation, the only other method for treatment for malignant diseases of the larynx, is employed, the use of an anesthetic is unnecessary. But irradiation, in spite of the recent advances in its use and the claims of cure which are made for it, should be used only when surgical intervention is inadvisable because the patient is a poor surgical or anesthetic risk or because the malignant condition is hopelessly advanced. No one denies that surgical intervention is the method of choice if the patient can be reasonably assured of a cure.

The operation for cancer of the larynx is necessarily a major operation and is attended by some dangers. Besides the complications incident to the operation itself, such as bleeding and infections, the patients are prone to have a respiratory complication. By this operation the surgeon establishes a new breathing channel, in laryngectomy, or interferes with the natural breathing apparatus, in laryngofissure, and any added irritation to the lungs, such as that caused by an anesthetic, should be eliminated as much as possible. Local anesthesia would be ideal if the nervous system of the patient were not too much upset. It can be used in laryngofissure. While some surgeons do only laryngectomies, laryngofissure has its place in the treatment of malignant growths of the larynx. It should be done perhaps more frequently now, since patients have become more cancer minded and come to the laryngologist early in the development of the disease, i. e., while it is still confined to a small anterior area, without fixation of the cord. The patients on whom I have performed laryngofissure have been spared their larynx and have not had a recurrence for periods up to twenty years. Some patients, however, are too nervous to undergo even laryngofissure under local anesthesia, and general anesthesia should be employed. It is conceded by most surgeons that in laryngectomy the patient should at least be somnolent during the greater part of the operation, because of the mental and nervous shock. The operation of laryngectomy for malignant growths of the larynx has been

changed by the untiring efforts of the pioneers, such as Gluck,[1] MacKenty,[2] Lynch[3] and New,[4] from a horrible and mutilating piece of work attended by high mortality to a comparatively simple and safe major surgical procedure practically without mortality. Salinger[5] gives four factors which contribute to this marked reduction in primary mortality: first, the practice of suturing the tracheal mucosa to the skin of the neck, a procedure originally devised by Gluck and later improved by many others; second, improved hemostasis and better technic in closure of the hypopharyngeal defect; third, the corking of the trachea to prevent aspiration of blood and mucus, as devised by MacKenty, and, fourth, the new method of inducing anesthesia. MacKenty[2c] stated that after laryngectomy the cough mechanism (air compression behind a closed glottis and sudden expulsion of air) is abolished. One of the most dreaded and fatal complications of laryngectomy is pneumonia. Hence, an anesthetic must be chosen which is nonirritating to the lungs. Ether, which is considered the safest anesthetic in other operations, is too irritating to the lungs and may cause excessive secretion of mucus. MacKenty[2a] limited ether narcosis to one-half hour, using a local anesthetic for the remainder of the time.

Rectal anesthetics have their drawback, as Beecher[6] claimed that they vary widely in their neurologic action on different persons and that wide variations in reactions may be encountered in a given person with a given dose from one time to another. These facts, plus the fact that the clinical dose of these agents is worrisomely near the lethal dose, make it clear that rectal anesthesia involves unnecessary dangers in most cases. The rate of absorption of the anesthetic agent cannot be satisfactorily controlled. However, avertin with amylene hydrate in mild doses, 75 to 80 mg. of tribromethanol per kilogram of body weight, is used widely with apparent safety but must be supplemented with another anesthetic. Crowe and Broyles[7] used chloroform to obviate the unpleasant effects of ether. But the danger of chloroform is too well

1. Gluck, T., and Soerensen, J.: Die chirurgische Therapie des Kehlkopfkarzinoms, Jahresk. f. ärztl. Fortbild., 1912, no. 2, p. 20.

2. MacKenty, J. E.: (*a*) The Technic and After-Treatment of Hemilaryngectomy and Total Laryngectomy, J. A. M. A. **69**:863 (Sept. 15) 1917; (*b*) Surgical Treatment of Laryngeal Cancer, Boston M. & S. J. **177**:110 (July 26) 1917; (*c*) Cancer of Larynx, Arch. Otolaryng. **3**:205 (March) 1926.

3. Lynch, R. C.: Cancer of the Larynx, South. M. J. **20**:119 (Feb.) 1927.

4. New, G. B.: A Two-Stage Laryngectomy, Surg., Gynec. & Obst. **47**:826 (Dec.) 1928.

5. Salinger, S.: Carcinoma of Larynx, Laryngoscope **45**:174 (March) 1935.

6. Beecher, H. K.: The Physiology of Anesthesia, New York, Oxford University Press, 1938.

7. Crowe, S. J., and Broyles, E. N.: Carcinoma of Larynx and Total Laryngectomy, Ann. Otol., Rhin. & Laryng. **47**:875 (Dec.) 1938.

known to permit its use at large by all anesthetists. According to Beecher,[8] the comparative death rates from the use of the various anesthetics are as follows: nitrogen monoxide, 1: 50,000; ether, 1: 5,000; cyclopropane, 1:3,500; chloroform, 1:2,000; spinal anesthetics, 1:1,500, and avertin with amylene hydrate 1: 1,200.

The ideal general anesthetic seems to be one that will cause somnolence and sufficient relaxation to prevent interference with the operator, will allow the patient to awaken immediately after the operation and at the same time will be perfectly safe and without irritation to the bronchi. At present such an anesthetic can be found in nitrogen monoxide and oxygen; this is quite safe to use for infants and is also safe for the aged and debilitated, such as patients with laryngeal carcinoma are sometimes found to be. There is no contraindication for the use of this anesthetic, and a patient may be kept asleep without any cyanosis. There is no advantage in use of avertin with amylene hydrate or of any other drug before the operation. The cough should not be interfered with or allayed by the sedative effect of any drugs administered preoperatively, and the gas mixture can be used directly from the start.

My method of procedure is as follows: If the patient is in good condition and does not require a preliminary tracheotomy, he is prepared in the usual manner and anesthetized with a mixture of 85 per cent nitrogen monoxide and 15 per cent oxygen under a pressure of from 5 to 10 mm. With this anesthetic he can be kept in a somnolent condition throughout the operation without the production of cyanosis. The operation is then begun and proceeds in the regular way until the entire larynx and part of the trachea are skeletonized. Then, with the patient under filtration anesthesia (procaine hydrochloride, 0.5 per cent and solution of epinephrine hydrochloride, 5 drops to the ounce), the trachea is severed, and a large tracheotomy tube wrapped around with tape, which is moistened with physiologic solution of sodium chloride, is inserted. The administration of nitrogen monoxide and oxygen is resumed by inserting the inner tube, which has the attachment for an artificial larynx. This is a tightly fitting inner tube with an extension outward and downward, which, in turn, fits into a rubber hose connected with the machine used for the administration of the nitrogen monoxide and oxygen. The anesthetist is then away from the field of operation and does not interfere with the surgeon. The moistened gauze serves two purposes. It prevents blood from entering the trachea and does not allow the escape of gas. The regularity with which the patient breathes can be watched by the contraction and relaxation of the gas bag, and the mixture can be regulated in accordance with the color of

8. Beecher, H. K.: Fatal Toxic Reactions Associated with Tribromethanol Anesthesia, J. A. M. A. **111**:122 (July 9) 1938.

the patient. The operation is then completed with comfort to patient and surgeon. This method has been routinely employed by the anesthetist at Sinai Hospital, Baltimore, and it has also been used at other hospitals in which I have operated. As soon as the operation is finished, the patient is awake and has good color and no ill effects from the operation or the anesthetic.

When laryngeal obstruction is present to begin with, the trachea can be opened, with the region under local infiltration anesthesia, in the place where later on, as stated previously, it will be severed from the larynx. The tracheotomy tube with its attachment can then be inserted and nitrogen monoxide and oxygen anesthesia induced in the regular way. The operation can proceed and be completed without further interference.

In laryngofissure, with highly nervous patients, for whom a general anesthetic is advisable, the tracheotomy can be done under local anesthesia, the tube inserted, nitrogen monoxide and oxygen administered and the operation performed in the usual way.

## CONCLUSIONS

Nitrogen monoxide and oxygen is an ideal anesthetic for use in laryngectomy. It is perfectly safe, is not irritating to the lungs and has no after effects. The patient is awake immediately on the conclusion of the operation. This anesthetic has been used by me for two years for old and debilitated patients as well as for the younger and stronger. While normally all my laryngofissures are done with the patient under local anesthesia, I had one patient to whom I had to administer a general anesthetic, and nitrogen monoxide and oxygen was used in the manner described, with equally good results.

Miss Genevieve South, anesthetist, Sinai Hospital, assisted in the work.

1908 Eutaw Place.

# CONCENTRATION OF MENTHOL IN THE SMOKE FROM MENTHOLATED CIGARETS

## A STUDY OF LOCAL AND SYSTEMIC EFFECTS

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Most of the cigarets on the market contain, in addition to tobacco, small amounts of other ingredients intended to improve the physical character or the flavor of the tobacco. In occasional instances a distinct flavor is imparted by one or another of these ingredients; this occurs with cigarets containing menthol. The question has been raised whether the daily inhalation of volatilized menthol in the amount present in such cigarets may be injurious, either from local or from systemic effects. The present study was undertaken to answer this question.

The irritation of the mucosa caused by nasal sprays containing menthol has been studied by Fox.[1] When 5 per cent menthol was applied daily for nine months, there was definite injury to the mucosa; there was some evidence of ill effects even with concentrations as low as 1 per cent. The statement has been made, but with no evidence given to support it, that menthol in cigaret smoke may be similarly injurious.[2]

When taken internally menthol does not accumulate in the body but is conjugated with glycuronic acid and is rapidly eliminated in the urine as mentholglycuronic acid.[3] In rabbits, 3,000 to 4,000 mg. of menthol per kilogram of body weight causes death in about half of the animals, while 300 to 400 mg. per kilogram induces no appreciable effect.[4] In spite of the fact that menthol is widely used in cough drops, tooth pastes, mouthwashes and nasal sprays, and, as a constituent of peppermint oil, in gum, candy and pastry, no instance of poisoning from menthol has been reported.

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From the Laboratory of Applied Physiology, Yale University.

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### AMOUNT OF MENTHOL IN MENTHOLATED CIGARETS

Mentholated cigarets of four different brands were purchased on the market over a period of six months and the content of menthol determined.[5] The weight of tobacco in the cigaret averaged 1.072 Gm., with extremes of 1.212 and 0.951 Gm.; the weight of the paper was practically constant at 58.8 mg.; the weight of the menthol averaged 1.64 mg., with extremes of 1.01 to 2.07 mg. These values for the amount of menthol probably do not correspond exactly with those put into the tobacco by the manufacturer. There is rapid loss of menthol when, as in the process of manufacture, the tobacco is exposed freely to the air. The loss of menthol from cigarets stored in unopened packages is slight, averaging about 0.00004 mg. per gram of tobacco per week.

### AMOUNT OF MENTHOL IN SMOKE FROM MENTHOLATED CIGARETS

A portion of the menthol in cigarets is destroyed by heat during smoking. The amount of menthol recovered in the smoke varied slightly with the rate of combustion, as influenced by the flow of air through the cigaret. At a flow of 200 cc. per minute an average of 52 per cent of the menthol appeared in the smoke; at 500 cc. per minute, 49 per cent, and at 1,000 cc. per minute, 45 per cent.

As a reasonable approximation it may be taken that not more than half the menthol contained in the cigaret can be drawn into the mouth with the smoke. Even if the entire cigaret were burned, the amount of menthol inhaled would be 1 mg. or less per cigaret.

### ABSORPTION OF MENTHOL

The questions of physiologic significance which turn on the quantity of menthol drawn in with the smoke are: (1) the amount of menthol absorbed from the mouth and respiratory passage which might exert a toxicologic action and (2) the concentration of menthol appearing in the fluids on the surface of the respiratory passages which might exert an irritant action.

The total amount of menthol drawn in with the smoke, placed here as a maximum of 1 mg. per cigaret, is not the amount absorbed, since a portion of the menthol is exhaled. In eighteen experiments carried

5. The menthol was removed from the tobacco by volatilization at 80 C. in a stream of air and collected in a solution of para-dimethylaminobenzaldehyde (0.5 Gm. in 100 cc. of 60 per cent sulfuric acid). The red color which developed when the solution was heated at 100 C. for three minutes was compared against a standardized solution of phenol red (phenolsulfonphthalein). Nonmentholated cigarets gave no reaction. The recovery of menthol from tobacco to which known amounts of menthol had been added was accurate to $\pm 2$ per cent.

out on men the expired air was collected during and after smoking (with inhalation) mentholated cigarets, each containing approximately 2 mg. of menthol; an average of 0.31 mg. of menthol was recovered from the expired air; the extremes were 0.25 and 0.37 mg. Thus, approximately 70 per cent of the menthol in the smoke inhaled is absorbed. A heavy smoker (sixty cigarets per day), inhaling the smoke, might, at the extreme, absorb 42 mg. of menthol in the course of a day; a moderate smoker (twenty cigarets), 14 mg., and a light smoker (five cigarets), 3.5 mg.

From a toxicologic point of view these amounts of menthol, ranging from 0.05 to 0.59 mg. per kilogram of body weight, are extremely small. The menthol absorbed from twenty cigarets would correspond to that obtained from four to seven mentholated cough drops.

### CONCENTRATION OF MENTHOL ACTING ON THE RESPIRATORY TRACT

Any irritant action of menthol on the mucosa of the respiratory tract would depend on the concentration of menthol developed in the fluid on this surface. This concentration would, in turn, depend both on the amount of menthol in the smoke and the extent of dilution with air in the respiratory tract. The mouth, not the chest, is used to draw in the smoke from a cigaret; the act is identical with sucking. In taking a puff the pharynx is shut off; the lips are closed about the cigaret and the cavity of the mouth is enlarged by the movement of the tongue. The amount of air that can be drawn into the mouth under these circumstances is limited. Measurements of the volume of air drawn in with a single puff from a cigaret gave an average value of 33 cc., with extremes of 22 cc. and 51 cc.

The number of puffs taken in smoking a cigaret is highly variable, depending on both the cigaret smoked and the smoker. Tightly packed cigarets burn more slowly than those loosely packed and therefore afford more puffs. The main variable, however, is the smoker. While reading, writing, playing cards or similarly occupied, he may take only three or four puffs from the entire cigaret; again, in moments of nervousness he may smoke with great rapidity. The observation of a large number of subjects who were habitual smokers, smoking the particular cigarets under study—and with their attention fixed on smoking—showed an average of seventeen puffs per cigaret, with extremes of thirteen and twenty-one. Each smoker was required to consume 5 cm. of the total 7 cm. length of the cigaret.

With the average values given previously, seventeen puffs per cigaret and 33 cc. of air drawn per puff, the total volume of smoke drawn

into the mouth per cigaret is 561 cc. This volume of smoke contains approximately 1 mg. of menthol. The concentration of menthol in air acting on the mouth is therefore 1 mg. in 561 cc. or 0.0018 mg. of menthol per cubic centimeter of air. This is not, however, the concentration in which menthol acts on the deeper respiratory tract. During inhalation smoke is first drawn into the mouth; the passage to the larynx is then opened and an inspiration made. The amount of air drawn in corresponds closely with that of a normal inspiration, or about 500 cc. The inhaled smoke is thus diluted with more than fifteen times its volume of fresh air. This diluted smoke is still further diluted with the stationary air in the respiratory passages, and the final mixture is exhaled, carrying with it, as we have shown, some 35 per cent of the total menthol taken in with the smoke. An occasional smoker, after taking the smoke into the mouth, draws it into the pharynx and exhales it through the nose; the dilution under these circumstances is only to the extent of the volume of air contained in the pharynx and in the nasal passages.

The only menthol which can exert an irritating action on the respiratory tract is that which is taken from the smoke and dissolved in the fluid on the surface of the tract. When water is exposed to air containing menthol vapor, menthol dissolves, and, with this removal, the concentration in the air falls until an equilibrium is reached with the rising concentration in the fluid. At body temperature the resulting distribution of menthol between air and fluid is in the proportion of 1:30, that is, 1 cc. of fluid contains thirty times as much menthol as 1 cc. of air to which it is exposed and is in equilibrium.

The theoretic maximum amount of menthol dissolved in the saliva and mucus of the upper respiratory tract (if none were lost from the air) would be 0.054 mg. per cubic centimeter (0.0018 x 30), or a 0.0054 per cent solution. A series of determinations of the amount of menthol in the saliva at various times after the subjects had smoked mentholated cigarets gave values considerably lower than the theoretic maximum. Immediately after the subjects had smoked, the average concentration of menthol was 0.00073 per cent, with extremes of 0.00062 and 0.00082 per cent; five minutes after they had smoked, the amount of menthol in the saliva was too small to permit quantitative determination.

The concentration of menthol acting on the deeper respiratory structures would be considerably less than that in the saliva. The concentration of menthol in air in equilibrium with the fluid on the surface of the entire respiratory tract immediately after the subjects had smoked mentholated cigarets was found to average 0.000043 mg. per cubic centimeter, with extremes of 0.000031 and 0.000053 mg. per cubic centimeter. At the solubility of menthol these values correspond to solutions of

menthol ranging between 0.000093 and 0.000159 per cent. During and after the smoking of a mentholated cigaret these extremely minute concentrations act on the mucous membranes for a total time of less than ten minutes.

### EFFECTS OF CONTINUOUS EXPOSURE TO MENTHOL VAPORS

The effect on rats of continuous exposure to menthol vapor in the concentration found in the smoke from mentholated cigarets was studied. Fifteen glass cages with sealed metal bottoms were used to house 30 rats. Through suitable tubes and controlling valves, 2 liters of air with or without menthol vapor were passed through each cage each minute. Menthol vapor was obtained by passing air through a large metal coil containing menthol, placed in an incubator at 30 C. At a flow of 15 liters per minute the air leaving the coil contained 0.0014 to 0.0016 mg. of menthol per cubic centimeter. Air containing this concentration of menthol was passed through five cages containing 10 rats. In a second train of five cages the air containing menthol was diluted with an equal volume of air, giving a concentration of 0.0007 to 0.0008 mg. of menthol per cubic centimeter. Fresh air was passed through the remaining five cages, containing 10 rats. The rats were exposed under these conditions continuously for six months, except fifteen minutes each day for renewing their food and for cleaning the cages.

During the first few days the rats in the cages containing the higher concentration of menthol suffered from some irritation of the eyes which caused them to blink frequently. At the end of this time they showed no further sign of discomfort. The rats were weighed once a week. The increase in weight for all three groups was approximately the same. At the end of the six month period the rats were killed and examined. There were no indications of inflammation or injury in the respiratory tract and no abnormalities in any other part of the body.

Although the concentration of menthol inhaled by rats in group 1 was approximately that in cigaret smoke from mentholated cigarets, the fact must be borne in mind that, contrary to the conditions in smoking, the menthol vapor was not diluted with fresh air during inhalation. The menthol vapor in a strength ten to fifteen times as great as that present during smoking acted directly on the surfaces of the entire respiratory tract.

The amount of menthol absorbed by the rats exposed to menthol vapor was not determined. It was, however, far in excess of the amount that would be absorbed if a man were to smoke mentholated cigarets continuously twenty-four hours a day for six months.

SUMMARY

The question as to the possible harmful effects of smoking cigarets containing menthol has been investigated.

The amount of menthol in mentholated cigarets on the American market was found to range between 1 and 2 mg. per cigaret.

Approximately one-half the menthol in the cigaret is lost by combustion; the other half appears in the smoke.

On inhalation of the smoke, approximately 70 per cent of the menthol is absorbed—a maximum of 0.7 mg. per cigaret, an amount so small as to be, even with heavy smoking, entirely innocuous.

The maximum concentration of menthol acting on the surface of the mouth and pharynx corresponds to an 0.000082 per cent solution; it is much lower in the deeper respiratory passages. Five minutes after a subject has smoked a mentholated cigaret, menthol cannot be found in the saliva or in the expired air.

Rats exposed continuously for six months to air containing menthol in the concentrations found in the smoke of mentholated cigarets suffered no ill health; there was no injury or inflammation of the respiratory tract.

CONCLUSIONS

Menthol added to tobacco in the amount now present in cigarets on the American market exerts no toxic or irritant action.

# ACUTE STREPTOCOCCIC LARYNGOTRACHEO-BRONCHITIS

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Among the many diseases of childhood, acute streptococcic laryngotracheobronchitis remains one of the least understood. Because of the infrequent and sporadic appearance of the disease there is much to be learned concerning the diagnosis, causes and management of the condition. The existence of the infection as a disease entity was recognized over one hundred years ago, in 1823, by the Frenchman, P. Blaud.[1] However, subsequent medical literature shows a surprisingly meager accumulation of new information about this disease as compared with the ever expanding knowledge of other respiratory infections.

The confusing clinical picture usually masks the original condition, with the result that the true identity of the infection is entirely overlooked. Its occurrence during epidemics of influenza and its close resemblance, in any one of its various stages, to diphtheria and pneumonia account for much of the confusion associated with the proper diagnosis and treatment of the disease.[2] The discrepancy in the mortality rate in the various age groups, with the necessity for different therapeutic management in these groups, indicates that a better understanding of the pathologic changes taking place is required. In view of the high mortality rate in children it is evident that there has been improper management of the condition. Available figures show the mortality rate to vary from 35 to 70 per cent.[3] Our observations indicate that the mortality rate varies inversely with the age. We believe this to be due to lack of immunity and to the laryngeal structure peculiar to infants and young children. For these reasons the disease manifests certain characteristics

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1. Blaud, P.: Nouvelles recherches sur la laryngo-trachéite connue sous le nom de croup, Paris, Gabon & Cie, 1823.

2. Weinstein, S.: Obstructive Laryngeal Dyspnea, Laryngoscope **48**:836-846 (Nov.) 1938.

3. Gatewood, E. T.: Bronchoscopic Observation of Laryngo-Tracheo-Bronchitis in Children with Obstructive Dyspnea, Virginia M. Monthly **63**:600-603 (Jan.) 1937.

in young children which cause the clinical picture to differ markedly from that seen in the adult. It is the condition seen in patients of the former group with which this paper deals.

## ETIOLOGY

"Nondiphtheritic," "fulminating," "infective" and "influenzal" are terms which have been used to designate types of laryngotracheobronchitis. In addition, when first seen in the later stages, the disease is often mistakenly diagnosed as pneumonia, bronchopneumonia and influenza. This confusion in diagnosis has prevented the accumulation of accurate figures as to the incidence and epidemiology of acute laryngotracheobronchitis. Reports by Jackson [4] and Howard [5] showed the predominating organism to be a streptococcus. Our experience leads us to believe that the majority of the cases of acute laryngotracheobronchitis are due to a streptococcic infection. To establish definitely that a streptococcus is the causative agent is difficult, because of the inaccessibility of the focus from which the material for cultures and smears should be taken. Although streptococcic pharyngitis is a part of the infection, cultures prepared from material taken from this region are unreliable because of the mixed growth of organisms usually present. Hence little reliance can be placed on laboratory findings and more attention must be given to the clinical features as a guide in governing the necessary therapy.

The disease is highly infectious and respects no age group. Children are especially susceptible, probably because of their lack of immunity to the invading organism.

## PATHOLOGY

No claim to originality in the description of any of the pathologic features of the disease is made. The descriptions given are the result of bronchoscopic observation in the living and study at necropsy. The two outstanding clinical features of the disease are early respiratory difficulty and subsequent fulminating toxemia. These invariably coexist to some degree. Among children, especially those under 3 years of age, these features are responsible for the high rate of mortality. The respiratory difficulty at the onset of the infection is due to a subglottic laryngeal stenosis. Anatomically the subglottic portion of the laryngotracheal segment is the narrowest part of the respiratory tract.[4] It is surrounded by the only complete ring of cartilage in the respiratory passage. Hence any swelling in this part is at the expense of the lumen of the airway. The stroma of this area is composed of highly vascular and loosely adherent connective tissue. This tissue rapidly becomes

4. Jackson, C., and Jackson, C. L.: Acute Laryngotracheobronchitis, J. A. M. A. **107**:929-932 (Sept. 19) 1936.

5. Howard, W. A.: The Use of Intubation and Tracheotomy in the Treatment of Obstructive Laryngitis in Children, J. Pediat. **12**:47-57 (Jan.) 1938.

edematous at the onset of the infection. Thus asphyxia often occurs from occlusion of the laryngeal lumen at this point. Furthermore, according to Heatly,[6] the cartilages of the larynx of an infant are much softer than those of an adult and therefore more likely to collapse from negative pressure in any laryngeal condition associated with stenosis. The clinical picture is one of high obstructive dyspnea, as described by Tucker.[7] If not checked early, however, the infection may extend downward to involve the trachea and bronchi. Successively this gives rise to the other types of obstructive dyspnea, first, low obstructive dyspnea and then bronchial obstructive dyspnea, resulting from the progressive downward occlusion of the trachea and later of the bronchi. When this occurs, the condition is often referred to as streptococcic pneumonia. According to Kinsella,[8] the inflammatory swelling is confined to the larynx, trachea and bronchi and does not extend into the alveoli. This is in direct contrast to pneumococcic pneumonia, in which the inflammatory process begins within the alveoli. However, the conditions are often confused, with the result that the patient soon expires under the usual therapy for pneumonia. The rapid onset, the type of dyspnea, the character of the sputum, the indefinite bilateral findings in the chest and the redness of the pharynx should enable the physician to distinguish so-called streptococcic pneumonia from pneumococcic pneumonia.

The occurrence of the infection during outbreaks of influenza often misleads one to make a diagnosis of influenza. Whether there is a symbiotic relationship between the streptococcus and the influenza bacillus and virus is not known. The appearance of the infection with influenza suggests this possibility, however.

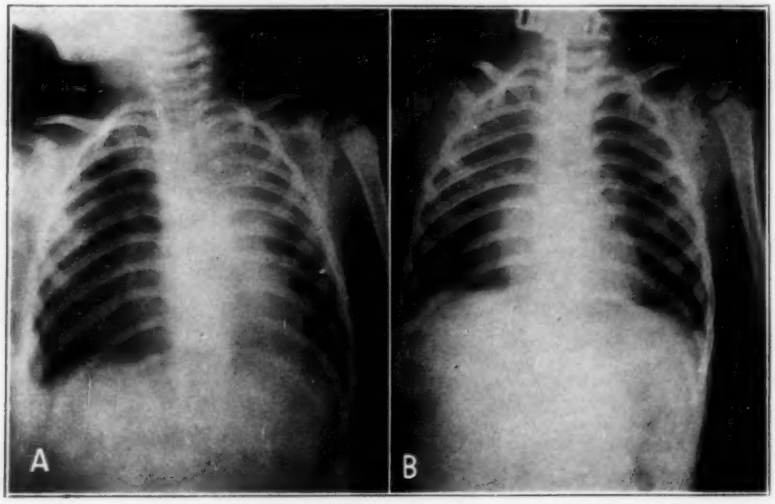
Bronchoscopic observations early in the course of the disease reveal congestion of the laryngopharynx and larynx with marked inflammatory swelling of the tissue below the vocal cords, which causes occlusion of the airway at this point. The trachea and bronchi, although inflamed, maintain an adequate airway. In those cases which progressed to a fatal termination, bronchoscopic examination showed a massive inflammatory swelling of the mucosal lining of the trachea and main bronchi. The intense congestion causes complete occlusion of the trachea and bronchi on expiration. During the forced inspiratory efforts, a slight opening in the airway can be observed. The swollen mucosa falls together to occlude the airway as the bronchoscope is withdrawn. Thick, tenacious secretions can be aspirated from the main bronchi. Earlier in the course of the disease it is these secretions and plugs which are responsible for the

6. Heatly, C. A.: The Larynx in Infancy, Arch. Otolaryng. **29**:90-103 (Jan.) 1939.

7. Tucker, G.: Obstructive Dyspnea, South. M. J. **25**:723-729 (July) 1932.

8. Kinsella, R. A.: Physical Diagnosis in Acute Diseases of the Chest, read at the Spring Medico-Military Symposium, Kansas City, Mo., March 14, 1940.

indefinite and rapidly changing findings in the chest. The patient, in his unsuccessful attempts to expel the secretions, dislodges and then reaspirates them into other parts of the bronchi, giving rise to the constantly changing conditions seen in roentgenograms of the chest. Roentgenograms taken at this time are often interpreted as showing pneumonic changes and lead to an incorrect diagnosis of pneumonia or bronchopneumonia. (See *A* in the figure.) This mistake is probably made more often than is realized. We have been consulted on several occasions only to find a patient, whose condition has been treated as pneumonia, in a moribund state beyond surgical or medical aid. In reality, the roentgen findings are due to the presence of atelectatic areas resulting from obstruction of the bronchi by mucus plugs and secretions (see *B*




Roentgenograms of a patient. *A*, on admission. A diagnosis of pneumonia of the upper lobe of the left lung was made on the basis of the roentgen study. *B*, twenty-four hours later, after tracheotomy and tracheobronchial aspiration.

in the figure). With increasing age, the ability of the inflammatory swelling to occlude the airway lessens. Usually after 3 years of age the trachea and bronchi have increased in diameter sufficiently to accommodate the intense swelling; hence the different clinical manifestations in the various age groups.

## SYMPTOMATOLOGY

The symptoms may be divided into those found in infants, those found in young children and those found in adults. We are chiefly concerned here with the symptoms seen in infants and young children with obstructive dyspnea. The diagnosis of acute streptococcic laryngotracheobronchitis is arrived at on the basis of the history, the manner of onset and the physical observations. The sudden onset of croup, fol-

lowed by increasing respiratory difficulty, in children up to 3 and 4 years of age during outbreaks of influenza should lead one to suspect this infection. The sudden onset, in a perfectly well child, of croup or wheezing that rapidly progresses to marked respiratory embarrassment within twenty-four to thirty-six hours is characteristic of the early phase of the disease (table).

The respiratory difficulty is manifested by high obstructive dyspnea due to the subglottic stenosis. There is suprasternal, supraclavicular and upper intercostal retraction during the forced inspiratory efforts. If the infection extends downward to involve the trachea and bronchi, the retraction during inspiration is noted in the lower intercostal and sub-

*Acute Streptococcic Laryngotracheobronchitis*

| Age and Sex of Patient | Symptoms | Duration of Illness on Admission | Treatment | | Termination |
|---|---|---|---|---|---|
| | | | Surgical | Medical | |
| 12 mo. ♀ | Obstructive dyspnea | 10 hr. | Tracheotomy | Azosulfamide * | Death after 3 days |
| 18 mo. ♀ | Obstructive dyspnea | 18 hr. | Tracheotomy | Azosulfamide | Recovery in 10 days |
| 19 mo. ♂ | Obstructive dyspnea | 36 hr. | Tracheotomy | Azosulfamide | Death after 5 days |
| 2½ yr. ♂ | Obstructive dyspnea | 24 hr. | Tracheotomy | Azosulfamide | Recovery in 7 days |
| 3 yr. ♀ | Obstructive dyspnea | 24 hr. | Tracheotomy | Sulfanilamide | Recovery in 14 days |
| 4 yr. ♀ | Obstructive dyspnea | 12 hr. | Tracheotomy | General care | Recovery in 21 days |
| 6½ yr. ♂ | Obstructive dyspnea | 16 hr. | Tracheotomy | Sulfanilamide | Death after 4 days |
| 7 yr. ♂ | Obstructive dyspnea | 36 hr. | Tracheotomy | Sulfanilamide | Recovery in 17 days |

* Azosulfamide is the disodium salt of (4-sulfamidophenyl-2′-azo-7′-acetylamino-1′-hydroxynaphthalene-3′, 6′-disulfonic acid). This substance has been known as prontosil soluble, as prontosil and as neoprontosil.

sternal spaces and the abdomen. In addition, expiration, normally an involuntary act, as well as inspiration, becomes a forced effort by necessity. With involvement of the lower respiratory tract, the chest findings are indefinite because of the constant changes occurring in the resipratory passages. If the respiratory difficulty is not relieved early, anoxemia soon results. The patient rapidly becomes toxic, and cyanosis appears. The cyanosis, a late sign of oxygen want, indicates that permanent damage to the pulmonary and respiratory centers is occurring. It is unfair to wait for these serious changes to supervene before relieving the obstructive dyspnea. Surgical intervention should not be reserved for the moribund patient. Collectively, the toxemia and the intense respiratory efforts soon exhaust the patient and lead to death.

Diphtheria can be differentiated by positive bacterial findings. The presence of a foreign body can be ascertained through physical findings and roentgen examination. Any further difficulty in differential diag-

nosis should be eliminated by a bronchoscopic examination. The direct laryngoscopic and bronchoscopic appearance is pathognomonic in patients with acute streptococcic laryngotracheobronchitis.

A typical case is cited:

A boy 2½ years of age went to bed perfectly well. Early the following morning the parents noticed that he was wheezing slightly and thought he had caught a cold. The mother stated that he was up and about and played as usual during the day. That evening, twelve hours before admission to the hospital, there was a sudden marked increase in the difficulty of breathing, which rapidly became worse. Two physicians were called in on separate occasions, but the breathing became progressively difficult. The child was admitted to the hospital with a temperature of 102.8 F., a respiratory rate of 40 per minute and a pulse rate of 145. The patient was alternately lying down and sitting up and restlessly shifting about, fighting for air. There was retraction in the suprasternal, supraclavicular, upper intercostal and epigastric spaces. Cyanosis was particularly marked around the lips and finger tips. Coarse rales were heard over both sides of the chest. Chest findings were constantly changing and were indefinite. Because of the obvious signs of high obstructive dyspnea, tracheotomy was immediately performed to relieve the respiratory difficulty. Cultures and smears were prepared directly from the trachea through the tracheotomic incision. After the operation was completed, 20,000 units of diphtheria antitoxin was given to the child. Two cubic centimeters of a 2.5 per cent solution of azosulfamide was given, then 1 cc. every two hours until 7 cc. had been given, after which the dosage was gradually reduced. The usual medical care supplemented this therapy. The patient became progressively better and was playing in bed without any evident discomfort on the third day after tracheotomy. The temperature was 100.2 F.; the pulse rate, 130, and the respiratory rate 15 per minute. At the end of the fourth day, the tracheotomy tube was removed, and the boy was able to breathe without difficulty. Convalescence was rapid, and the child was discharged from the hospital in care of the family physician one week after entry. Cultures of material taken at tracheotomy showed a pure growth of Streptococcus haemolyticus.

### TREATMENT

Management of the infection is chiefly concerned with relief of the obstruction and the toxemia. The toxemia should be treated as of streptococcic origin until proved otherwise. With the clinical efficacy of the sulfanilamide compounds established, this treatment should not be neglected. Drug therapy should be instituted when the patient is first seen. Sulfanilamide or one of its derivatives, however, is inadequate in itself, as it does not remedy the laryngeal obstruction. The laryngeal dyspnea presents a problem of surgical relief and not one of medical management. With a sudden onset and fulminating course, surgical intervention is usually necessary within twenty-four hours after the appearance of the first symptoms.

For giving a sulfanilamide compound we prescribe a dosage of 1 grain per pound (0.12 Gm. per kilogram) of body weight per day, to be taken at three or four hour intervals. This, however, does not apply in the earlier stages, when the amount should be greater, after which it is

reduced to the level mentioned. The usual precautions in detecting sensitivity to the drug should not be overlooked.

Tracheotomy is performed immediately, but in an orderly manner, when signs of high obstructive dyspnea are present. Delaying surgical intervention in the presence of high obstructive dyspnea is unfair to the patient and lessens his chances of recovery. Tracheotomy affords the most practical and efficient method by which the laryngeal dyspnea and the tracheal obstruction can be relieved. The tracheotomy tube short cuts the air, thus increasing the efficiency of, and reducing, the respiratory effort. The respiratory rate is diminished, a return of mental alertness ensues, and rest is induced. These changes combat shock and lessen the danger of circulatory collapse. The tracheotomy prolongs life sufficiently to bring into effective action the chemotherapeutic agents employed. The tracheotomy further affords a convenient opening through which the trachea and bronchi may be aspirated. Removal of the tenacious secretions and plugs is necessary during the first several days of the illness and can be accomplished in this manner with a minimum of effort to both the patient and the physician. Aspiration of the thick secretions and plugs is facilitated by introducing several cubic centimeters of physiologic solution of sodium chloride in the tracheotomy tube and immediately aspirating the trachea and bronchi with a rubber catheter. The saline solution dilutes the thick secretions and dislodges the plugs, permitting their easy removal.

Bronchoscopic treatment and intubation also have been employed to relieve dyspnea. Results, however, have not been encouraging. The very nature of the infection precludes the use of intubation. This method does not afford a means by which frequent removal of the thick secretions and plugs can be accomplished. The secretions must be removed in order to secure adequate alveolar ventilation. Likewise, bronchoscopic removal of the secretions and plugs further exhausts an already worn-out patient. The time consumed in the procedure, which usually must be repeated on numerous occasions, makes the method impracticable. Even though the obstructing secretions can be removed by bronchoscopic procedure, the laryngeal dyspnea is not permanently remedied by this treatment. However, bronchoscopic removal of secretions through the tracheotomic opening is occasionally necessary, when aspiration by catheter is unsuccessful.

The tracheotomy tube should be changed by the third or fourth day, by which time a fistula has fairly well formed. As soon as the toxic symptoms and the intermittent attacks of obstructive dyspnea have disappeared, the tracheotomy tube is permanently removed. This usually can be done by the end of the first week if the patient is progressing satisfactorily. Extension of the infection to the trachea because of the tracheotomic procedure is rare with the use of sulfanilamide or of one of its derivatives.

Cultures prepared from the trachea during tracheotomy will give the most reliable evidence of the causative agent.

Oxygen-helium inhalations, administration of fluids, nasal feedings and transfusions often are supplemental requisites in combating the toxemia. The use of atropine and of the derivatives of opium is absolutely contraindicated. Opium paralyzes the respiratory center and inhibits the cough reflex. The expulsion of the obstructing secretions is prevented, and the life-sustaining respiratory efforts are reduced. Atropine further thickens the tenacious secretions, increasing the difficulty in their expulsion. Thus the patient's efforts in his fight for air are prevented, and he slowly sleeps his life away.

The anoxemia resulting from the laryngotracheal obstruction is best combated through the use of a helium-oxygen mixture rather than of oxygen alone. The use of the mixture is based on the fact that the velocity of passage of a gas through a small orifice is proportional to the square root of the density of the gas. The pressure required for the passage of a mixture of 21 parts of oxygen and 79 parts of helium is approximately one-half that needed for the passage of air.[9] Use of the gas mixture reduces the respiratory effort necessary for ventilation distal to the obstruction. Increased pressure facilitates entrance of the gas into the pulmonary system. This can be obtained by using a closed circuit rebreathing apparatus attached to the tracheotomy opening or by introducing a catheter carrying the mixture directly into the tracheotomy tube. The mixture is not irritating and can be used continuously for twenty-four hours or more if necessary.

The patient's nutrition should not be neglected. Administration of the child's formula is best accomplished through a nasal feeding tube when nourishment cannot be taken by mouth. The intake of fluids must be maintained at a normal level. Small transfusions are a necessary adjuvant in combating the anoxemia.

## SUMMARY

The pitfalls encountered in arriving at a correct diagnosis of acute streptococcic laryngotracheobronchitis are discussed.

The early occurrence of subglottic stenosis in infants and young children produces the alarming clinical picture usually encountered when the patient is first seen.

The immediate relief of the high obstructive dyspnea by tracheotomy and the institution of sulfanilamide therapy are recommended.

Constant supportive care by the pediatrician is a necessary requisite in bolstering the patient's defensive mechanisms.

607-608 Commerce Trust Building.

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# POSSIBLE DEDUCTIONS OF ENDOCRINE SIGNIFICANCE FROM ROENTGENOGRAMS OF THE SINUSES AND MASTOID

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The aim of this paper is to present a preliminary treatise on three problems of endocrine background closely allied to otolaryngology. These are:

1. Does pituitary activity exert any influence on the susceptibility of the petrous pyramid to infection?

2. What can the otolaryngologist tell of his patient's intelligence quotient by roentgenograms of the sinuses and mastoid?

3. Do the characteristics of the skull observed in cases of hyperpituitarism predispose to the complication of osteomyelitis in cases of frontal sinusitis?

## DOES PITUITARY ACTIVITY EXERT ANY INFLUENCE ON THE SUSCEPTIBILITY OF THE PETROUS PYRAMID TO INFECTIONS?

The work of Hector Mortimer and his associates on cranial dysplasias of pituitary origin [1] presents a division of human craniums into four groups, according to pituitary levels. Levene, Johnson, Lowman and Wissing [2] described the four types thus:

*Type 1.* Overactivity of the anterior lobe produces an expansion of the trabecular network of bone. It may be likened to the effect of yeast on dough. The diploic table of the skull becomes expanded and more vascular, while the inner and outer tables are thinned. In consequence, those structures developing in diploe (the paranasal sinuses and mastoid cells) become enlarged. This mechanism finds its culmination in acromegaly. Here the vault is thick, but light in structure, the diploe greatly expanded and the paranasal sinuses and mastoid cells hyperpneumatized. It is this type of skull which also shows pneumatization of the petrous pyramid and apex. Lesser degrees of these changes are encountered more fre-

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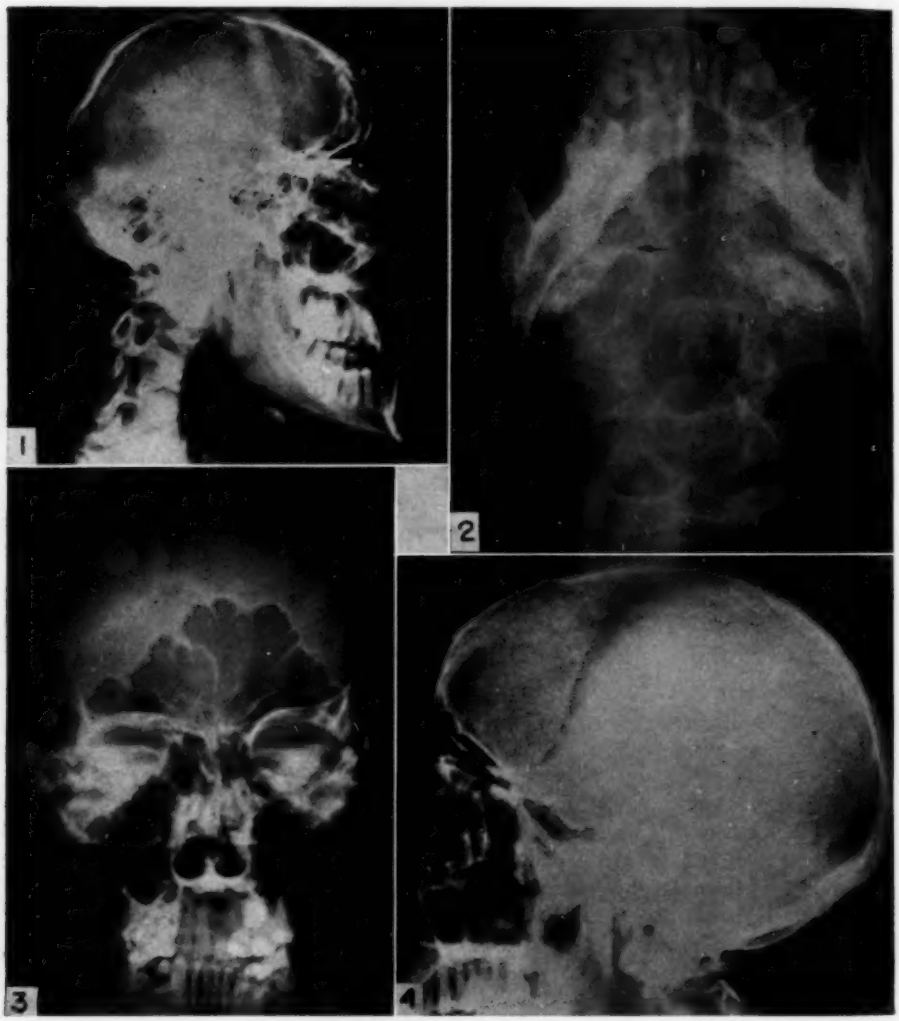
Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society, Inc., June 1940.

1. Mortimer, H.; Levene, G., and Rowe, A. W.: Radiology **29**:135 (Aug.) 1937.

2. Levene, G.; Johnson, L. F.; Lowman, R. M., and Wissing, E. G.: Endocrinology **22**:521 (May) 1938.

quently than true acromegaly. The skulls of these patients, however, possess the same structural characteristics. The diploe is expanded and more vascular, and the paranasal sinuses and mastoids are hyperpneumatized. This type of cranial dysplasia may vary in degree from slight departures from normal to a state properly designated as subacromegaly.




Figs. 1 to 4.—Roentgenograms of type 1 skulls (Levene, Johnson, Lowman and Wissing.[2]

*Type 2.* Post-adolescent or acquired deficiency of the anterior lobe results in skull changes which are just opposite to those produced by overactivity. Here we find an absence of diploic expansion. As a result, the sinuses and mastoid cells are poorly pneumatized. The skull is dense and hard. . . . The petrous

pyramid is sclerotic and the tip nonpneumatized. This type is frequently associated with obesity.

*Type 3.* Overactivity of the anterior lobe is frequently followed by hypofunctional involution. The skull roentgenograms of such patients present the typical features characteristic of each phase. The diploe is expanded, and the

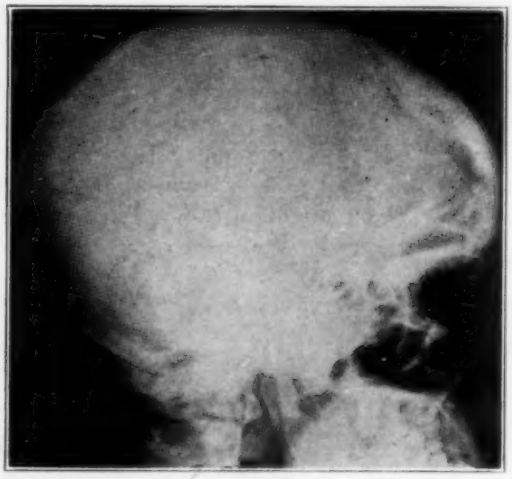
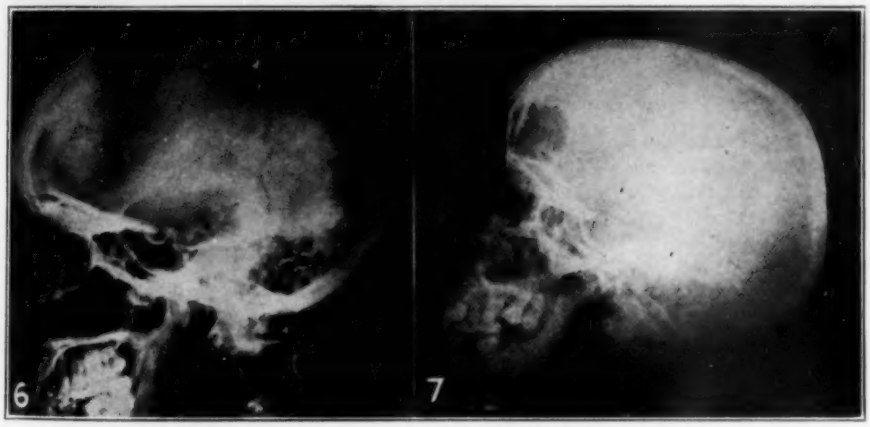


Fig. 5.—Roentgenogram of a type 2 skull (Levene, Johnson, Lowman and Wissing [2]).

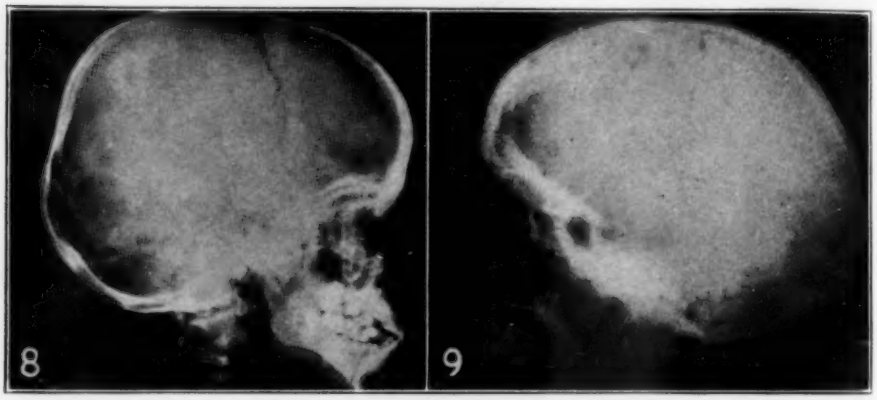



Figs. 6 and 7.—Roentgenograms of type 3 skulls (fig. 6, Levene, Johnson, Lowman and Wissing;[2] fig. 7, Mortimer, H.; Levene, G., and Rowe, A. W.: Cranial Dysplasias of Pituitary Origin, *Radiology* **29**:279 [Sept.] 1937).

paranasal sinuses and mastoid cells hyperpneumatized. These are the residual evidences of the stage of overactivity. In addition, however, there is a secondary sclerosis beginning in the inner table and extending into the diploe. The changes are most marked in the frontal bone. The latter findings indicate the advent of a variable degree of anterior lobe failure.

*Type 4.* Congenital or pre-adolescent deficiency of the anterior lobe produces the type recognized as the "pituitary dwarf." The skull roentgenograms of these patients show a striking absence of diploic expansion, so that the outer and inner tables are in close approximation. As a result, the vault is thin, hard, dense and not vascular. The paranasal sinuses and mastoid cells are very poorly pneumatized, the petrous pyramids dense and cancellous. The frontal sinuses are frequently absent. The face and jaws are small and dentition is delayed.

That part of Mortimer's study of the sinuses conducted at the Robert Dawson Evans Memorial for Clinical Research and Preventive Medicine in Boston was synchronous with the rekindled interest in diseases of the petrous pyramid. As a consultant at the Evans Memorial I watched the progress of this typing of skulls. It appeared possible to me that the pituitary gland might affect the structure of the petrous pyramid and, in turn, that the structure of the pyramid might have




Figs. 8 and 9.—Roentgenograms of type 4 skulls (fig. 8, Levene, Johnson, Lowman and Wissing;[2] fig. 9, Mortimer, H.; Levene, G., and Rowe, A. W.: Cranial Dysplasias of Pituitary Origin, *Radiology* **29**:279 [Sept.] 1937).

some influence on its susceptibility to infection. I therefore presented this possibility to the department of roentgenology at the Evans Memorial, and the roentgenologic study of petrous pyramids began.

The results of roentgen studies showed a rather striking parallel between the type of skull and the structure of the petrous pyramid. In other words, a skull with large sinuses and mastoids (type 1) was likely to show hyperpneumatization of the petrous pyramid, and a skull showing small sinuses and a sclerotic brain case was likely to have a dense, sclerotic petrous pyramid. It must be stated that, while the analogy between the petrous pyramid and the sinuses and skull is not always absolute, it appears to be the rule rather than the exception.

This observation is of inestimable clinical value in that otologists may immediately discern from the roentgenogram the likelihood of the

development of petrositis in the individual case of middle ear disease. This information should also alter one's operative program, as it is obviously essential when operating on a large pneumatic mastoid with hyperpneumatization of the pyramid to be most meticulous in exenterating the mastoid cavity, to remove every cell in the hope that one's thoroughness may prevent the dreaded complication of petrositis.

A hyperpneumatic condition of the petrous pyramid appears to be the result of hyperactivity of the anterior lobe of the pituitary gland. Petrositis is encountered in those patients having pneumatic petrous pyramids, or, in other words, in those who have an overactive hypophysis. The influence of the pituitary gland on the pyramid, as evidenced by roentgen study, is of definite clinical value.

## WHAT CAN THE OTOLARYNGOLOGIST TELL OF HIS PATIENT'S INTELLIGENCE QUOTIENT BY ROENTGENOGRAMS OF THE SINUSES AND MASTOID?

The theory that pituitary activity appeared to be in possible relationship to a person's intelligence quotient was first expressed, so far as I can learn, by the late Dr. Allan Winter Rowe, one time director of the Evans Memorial. This study and many others of significance in the field of endocrinology were just beginning when they were abruptly halted by Dr. Rowe's untimely death. It was certainly five or six years ago that he spoke of this possibility to me. It was his belief that the person with a hyperactive pituitary gland possessed a higher degree of intelligence than the average person and, conversely, that the patient with a hypoactive pituitary gland was likely to be of inferior intelligence.

Since the typing of craniums by Mortimer, I have speculated in regard to each sinal and mastoid roentgenogram that I have examined on: first, the degree of pituitary activity, as determined by the structure of the skull, and, second, the probable intelligence quotient of the patient, using the structure of the skull as the guide to the pituitary level. Some interesting observations have been made which tend to support the theory that a high intelligence quotient is associated with overactivity of the pituitary gland.

I shall briefly enumerate 5 cases as examples:

The first 3 cases are reported because they present interesting hereditary evidence of endocrine activity and accomplishment.

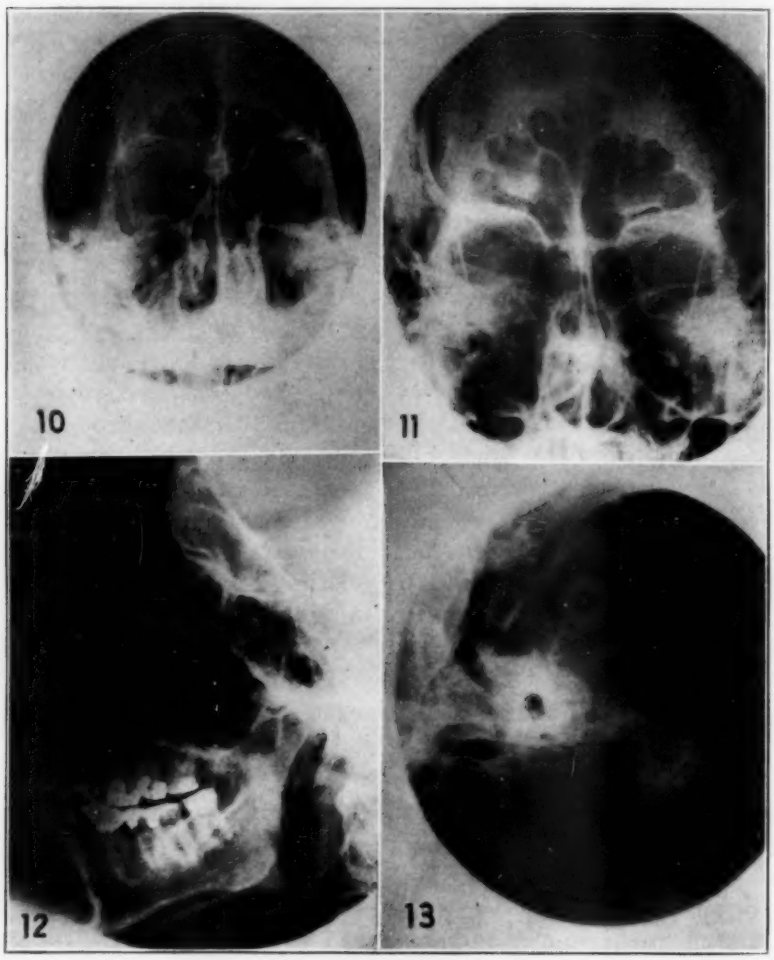
### REPORT OF CASES

CASE 1.—A man 80 years of age, whose school attendance ceased after his graduation from an academy, founded and continues to operate an industry which, from humble beginnings, has grown to be one of the largest of its kind in the world.

CASE 2.—A 40 year old man, the son of the patient in case 1, consulted me concerning chronic maxillary sinusitis on the right. This patient had the largest

sinuses I have ever seen in any person not acromegalic. Inquiry into his scholastic record revealed that he was graduated with Phi Beta Kappa and summa cum laude honors from Amherst College.

CASE 3.—This patient is a boy 10 years of age and is the grandson of the patient in case 1 and the son of the patient in case 2. At operation for acute mastoiditis a




Figs. 10 to 13.—Roentgenograms of patients. *10* (case 1) shows the large sinuses typical of hyperpituitarism, characteristic of the type 1 skull; *11* and *12*, the patient in case 2; *13* (case 3), hyperpneumatization of the mastoid (type 1).

mastoid of remarkable size was found, with most extensive pneumatization in the zygomatic region. The patient attends an exclusive boys' school, and inquiry from one of his masters revealed that he is unusually brilliant.

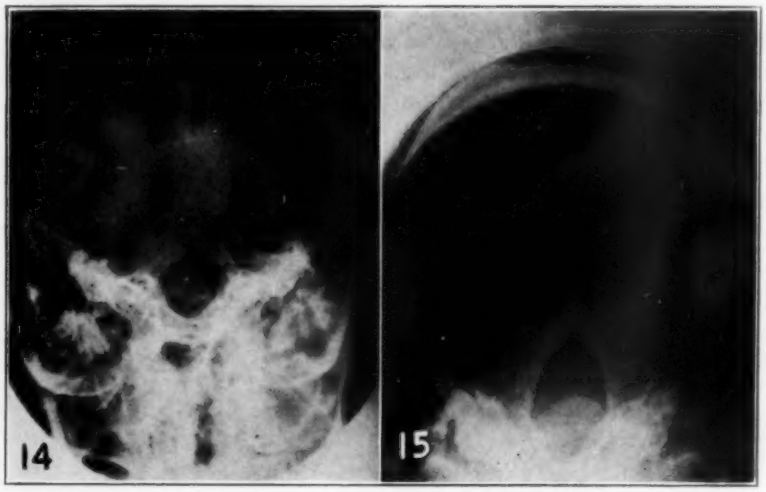
CASE 4.—A man 28 years of age, with acute mastoiditis and petrositis, had the largest mastoid that I have ever seen. On inquiry, I found that he had a Phi Beta

Kappa key and that he had obtained the degree of Doctor of Philosophy in psychology from Harvard.

CASE 5.—A 17 year old girl with acute mastoiditis and petrositis had an enormous mastoid, with hyperpneumatization of the petrous pyramid. During the course of her illness, which lasted eight months before her final recovery, she had involvement of the fifth and seventh nerves. There was no involvement of the sixth nerve. She was the honor pupil from a girls' school of the highest standing and won high honors on the college entrance board examinations.

Innumerable cases of persons with type 1 skulls and with large sinuses and mastoids who have realized high attainment in scholarship could be enumerated if time and space warranted.

This study has included a great many persons of scholastic attainment, as measured by the conventional standards of Phi Beta Kappa,




Figs. 14 to 15.—Roentgenograms of patients. *14* shows hyperpneumatization of the mastoid and the petrous pyramid (case 4); *15*, the patient in case 5.

magna cum laude or cum laude. Doubtless many students with high intelligence quotients and with craniums which fall into types 1 and 3 are classified by college standards as merely average, for the probable reason that their versatility has led them into athletics and literary or other extracurricular activities which have given them insufficient time for the concentration on academic work required for the attainment of high honors. Realizing this pitfall, I have made no study of the average student.

As consultant at two state hospitals for the mentally deficient, I have had the opportunity to examine many sinal and mastoid roentgenograms of these patients. For the most part, the roentgenograms of persons who are mentally defective show remarkably small sinuses. Benda's

study of the craniums of persons with mongolism at the Wrentham State School, Wrentham, Mass., reveals a fairly consistent absence of both frontal and sphenoid sinuses, as well as a consistently small sphenoid bone, in patients with mongolism.

I have attempted, in this part of the paper, to present the thought that roentgenograms of the sinuses and mastoid may be used as a guide to the patient's intelligence as well as a guide to his pituitary level.

### DO THE CHARACTERISTICS OF THE SKULL OBSERVED IN CASES OF HYPERPITUITARISM PREDISPOSE TO THE COMPLICATION OF OSTEOMYELITIS IN FRONTAL SINUSITIS?

Osteomyelitis of the frontal bone complicating frontal sinusitis is one of the most devastating lesions to be found in all human disease.

It differs from osteomyelitis of the long bones in that there is little, if any, attempt on the part of nature at limitation or sequestration of the osteomyelitic process, but rather, the disease spreads until the entire calvarium may be involved or until the progress of the disease is halted by intracranial complications and death.

It has been shown by Furstenberg [3] that osteomyelitis of the frontal bone spreads by way of the meningeal vessels. If one recalls that the outer table of the skull is nourished by the blood coming from the external periosteum and returning to it and likewise that the inner table receives its blood supply from the dura, or inner periosteum, certain phenomena associated with this disease are readily accounted for. These are:

1. Extradural, subdural and brain abscesses by means of retrograde thrombophlebitis.

2. Septicemia from thrombosis of the sinuses of the dura, chiefly the longitudinal.

3. The involvement of the inner table of the skull, with an apparently normal outer table.

4. The presence of distant osteomyelitic foci about the skull, with normal bone intervening.

The pathologic appearance, diagnosis and treatment of osteomyelitis of the frontal bone have been ably presented by Mosher and Judd [4] and by Furstenberg.[3] One sentence of Mosher's, referring to the doughy edema of the forehead, is so delightfully clear and simple and so important that its repetition is always in order—"Remember that osteomyelitis writes across the patient's brow not only the diagnosis but the treatment."

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3. Furstenberg, A. C.: Ann. Otol., Rhin. & Laryng. **40**:996 (Dec.) 1931.
4. Mosher, H. P., and Judd, D. K.: Laryngoscope **43**:153 (March) 1933.

It will be recalled that in craniums of types 1 and 3 as described in the classification into four groups according to pituitary levels, there was found increased vascularity of the skull, as well as certain structural characteristics, the result of hyperactivity of the pituitary gland.

The development of osteomyelitis complicating frontal sinusitis appears to be dependent on two factors:

1. The blood supply.
2. The structure of the skull.

These two factors, apparently essential to osteomyelitis of the skull, are found in types 1 and 3—the types indicative of hyperpituitarism.

Further comment on the first requisite of osteomyelitis, namely, the blood supply, appears unnecessary. In all cases, however, of frontal sinusitis the roentgenogram should be scrutinized for the presence of blood vessels proximal to the infected sinus. Let me conclude my comment on this aspect of osteomyelitis with Mortimer's [5] observation that there is increased vascularity of the skull in hyperpituitarism.

The second requisite for osteomyelitis of the frontal bone appears to be a structural one. The rarefied, spongy type of skull with large sinuses has been herein referred to as associated with hyperactivity of the pituitary gland. All the 14 patients with osteomyelitis of the frontal bone whom I have treated have shown craniums with the structural characteristics of hyperpituitarism.

In conclusion, it seems possible to infer that hyperactivity of the pituitary gland causes certain changes in the skull which are favorable for the development of osteomyelitis.

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5. Mortimer, H.: Radiology **28**:5 (Jan.) 1937.

# ACUTE SUPPURATIVE OTITIS MEDIA

## A REVIEW OF CASES ENCOUNTERED DURING A FIVE YEAR PERIOD

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In 1935 Domagk described his experiments with a sulfanilamide compound and inspired the medical profession to renewed activity in combating bacterial infections with chemotherapy. About a year later Colebrook proclaimed that sulfanilamide was practically a specific for infections due to the beta type of hemolytic streptococcus. Since that time sulfanilamide has been widely used against infections caused by a variety of organisms. Derivatives of the drug have been developed and, like the parent substance, have also been extensively used. Much has been written on this phase of chemotherapy, not only to advocate the use of sulfanilamide and its derivatives, but also to point out possible dangers associated with their administration.

It was only natural that sulfanilamide should have received an early and general reception in the field of otolaryngology, where the hemolytic streptococcus plays such a prominent part in disease. Since the introduction of this drug and its derivatives there has been a definite improvement in the results of treatment in acute suppurative otitis media. Opinions vary, however, as to how much credit should be given chemotherapy for this improvement. It is well to remember that the successful treatment of disease depends primarily on the accuracy of diagnosis and clinical judgment, rather than on the efficacy of any therapeutic agent.

In order to gain a better understanding of the contribution made by chemotherapy in the treatment of acute suppurative otitis media, a study of the cases of all patients with this disease treated at the Royal Victoria Hospital during the period from 1935 to the close of 1939 has been undertaken. This period has been chosen in order to include the data of at least the two years immediately preceding the use of sulfanilamide. With the permission of Dr. Wilder Penfield, patients with acute suppurative otitis media treated at the Montreal Neurological Institute have been included in this study. It has been necessary to do this in order to follow up patients with intracranial complications who have been transferred to that institution for further treatment.

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From the Royal Victoria Hospital and the Montreal Neurological Institute.

Only the cases of patients admitted to the hospital wards have been investigated. The cases of patients treated in clinics as ambulatory patients have been excluded. A group of 754 cases has been studied from several aspects, with a view to exposing those various influences that might affect the results of treatment. Whenever possible the information acquired has been arranged in tabular form.

In table 1 the cases have been grouped according to the bacteriologic diagnosis. That such a diagnosis has been more diligently sought during

TABLE 1.—*Bacteriologic Diagnosis in Cases of Acute Suppurative Otitis Media*

| Bacteriologic Observation | Cases in Which Observation Was Made | | | | | | Percentage of Cases in Which Cultures Were Made |
|---|---|---|---|---|---|---|---|
| | 1935 | 1936 | 1937 | 1938 | 1939 | Total | |
| Str. haemolyticus beta | 57 | 51 | 63 | 71 | 67 | 309 | 58.7 |
| Pneumococcus type III | 15 | 7 | 13 | 18 | 18 | 71 | 13.5 |
| Pneumococcus (other types) | 15 | 10 | 9 | 17 | 16 | 67 | 12.7 |
| Staph. pyogenes | 5 | 6 | 4 | 14 | 11 | 40 | 7.6 |
| No growth | 10 | 5 | 3 | 4 | 2 | 24 | |
| No culture | 56 | 54 | 58 | 25 | 11 | 204 | |
| Organisms specified in tables 3 and 4 | 2 | 8 | 11 | 7 | 11 | 39 | 7.4 |
| Total cases | 160 | 141 | 161 | 156 | 136 | 754 | |

TABLE 2.—*Age Incidence of Bacterial Types of Acute Suppurative Otitis Media 1935 to 1939*

| Bacterial Type | Cases in Which Bacterial Type Was Found | | | | | |
|---|---|---|---|---|---|---|
| | Years 0 to 10 | Years 11 to 20 | Years 21 to 30 | Years 31 to 50 | Years Over 50 | Total |
| Str. haemolyticus beta | 203 | 48 | 22 | 30 | 6 | 309 |
| Pneumococcus type III | 12 | 3 | 12 | 31 | 13 | 71 |
| Pneumococcus (other types) | 34 | 8 | 6 | 13 | 6 | 67 |
| Staph. pyogenes | 15 | 7 | 3 | 11 | 4 | 40 |

the last two years of this series is evident. Cases in which infection was due to a pneumococcus other than type III have been grouped together on account of the small series and the tendency in the earlier years of this period for bacteriologists to report the collective type IV. The predominating group, however, was type I. In a few cases Staphylococcus pyogenes was found in association with Streptococcus haemolyticus beta, but it has not been referred to, on the assumption that it was a contaminant.

Table 2 presents the age incidence for infections due to the more important organisms. Of the patients infected with Str. haemolyticus beta, 81 per cent were under the age of 21 years. Of the patients infected with Pneumococcus type III, 78 per cent were over 21 years.

In tables 3 and 4 a comparison is made between the number of patients requiring mastoidectomy and the number of those discharged from the hospital without mastoidectomy. In the study of the group of infections due to Pneumococcus type III, these figures can be used to compute the percentage of cases of acute suppurative otitis media complicated by acute mastoiditis. This is not true of other groups, on

TABLE 3.—*Bacteriologic Diagnosis in Cases of Acute Suppurative Otitis Media in Which Mastoidectomy Was Not Required*

| Bacteriologic Observation | Cases in Which Observation Was Made | | | | | |
|---|---|---|---|---|---|---|
| | 1935 | 1936 | 1937 | 1938 | 1939 | Total |
| Str. haemolyticus beta | 16 | 18 | 25 | 30 | 31 | 120 |
| Pneumococcus type III | 2 | 2 | 4 | 3 | 9 | 20 |
| Pneumococcus (other types) | 12 | 8 | 3 | 11 | 15 | 49 |
| Staph. pyogenes | 5 | 5 | 2 | 10 | 10 | 32 |
| No growth | 7 | 3 | 2 | 0 | 2 | 14 |
| No culture | 46 | 41 | 45 | 21 | 9 | 162 |
| Other organisms * | 1 | 7 | 9 | 6 | 9 | 32 |
| Total | 89 | 84 | 90 | 81 | 85 | 429 |

* These for the five year period were: Staphylococcus epidermidis albus, 14 cases; Bacillus subtilis, 1; Haemophilus influenzae, 8; diphtheroids, 3; micrococci, 5; Staphylococcus candicans, 1.

TABLE 4.—*Bacteriologic Diagnosis in Cases of Acute Suppurative Otitis Media in Which Mastoidectomy Was Required*

| Bacteriologic Observation | Cases in Which Observation Was Made | | | | | |
|---|---|---|---|---|---|---|
| | 1935 | 1936 | 1937 | 1938 | 1939 | Total |
| Str. haemolyticus beta | 41 | 33 | 38 | 41 | 36 | 189 |
| Pneumococcus type III | 13 | 5 | 9 | 15 | 9 | 51 |
| Pneumococcus (other types) | 3 | 2 | 6 | 6 | 1 | 18 |
| Staph. pyogenes | 0 | 1 | 2 | 4 | 1 | 8 |
| No growth | 3 | 2 | 1 | 4 | 0 | 10 |
| No culture | 10 | 13 | 13 | 4 | 2 | 42 |
| Other organisms * | 1 | 1 | 2 | 1 | 2 | 7 |
| Total | 71 | 57 | 71 | 75 | 51 | 325 |

* These for the five year period were: Staphylococcus epidermidis albus, 2 cases; Haemophilus influenzae, 1; diphtheroids, 1; micrococci, 1; Staphylococcus candicans, 1; Streptococcus viridans, 1.

account of the exclusion of clinical cases. It has been the policy of the Royal Victoria Hospital to admit all patients suffering from acute suppurative otitis media caused by Pneumococcus type III to hospital beds. In 58.7 per cent of the cases in which a bacteriologic diagnosis was made, the infection was due to Str. haemolyticus beta and 61 per cent of the patients required mastoidectomy. In the second largest group of cases in which a bacteriologic diagnosis was made, representing 13.5 per cent, the infection was due to Pneumococcus type III. Of the patients with infection of this origin, 71.8 per cent required mastoid-

ectomy. The third largest group of bacteriologically diagnosed cases was that in which infection was due to Pneumococci other than type III. This group included 12.7 per cent of cases, in 27 per cent of which the patients required mastoidectomy. In the cases in which mastoidectomy was required and in which the bacteriologic origin is known, 94.5 per cent of the infections were due to Str. haemolyticus beta or some type of Pneumococcus. In our experience Staph. pyogenes has frequently proved to be a contaminant and is not considered as one of the important causes of acute otitis media.

The percentage of patients in this series requiring mastoidectomy is particularly high and, as has been suggested, does not represent the true percentage of patients with acute suppurative otitis media having mastoid involvement. It is important to realize that a large number of patients are admitted to hospitals after a diagnosis of acute suppurative mastoiditis has been made. In order to demonstrate this statement I have presented, in table 5, the number of patients operated on for this

TABLE 5.—*Preoperative Hospitalization for Patients Requiring Mastoidectomy*

| | Patient Operated On Within Given Period | | | | | |
|---|---|---|---|---|---|---|
| Preoperative Period in Hospital | 1935 | 1936 | 1937 | 1938 | 1939 | Total |
| Two days or less | 40 (56.3%) | 35 (61.4%) | 41 (57.7%) | 46 (61.3%) | 33 (66%) | 195 (60%) |
| Seven days or less | 52 (73.2%) | 44 (77.2%) | 49 (69%) | 57 (76%) | 43 (86%) | 245 (75.3%) |

complication within two days of admission to the hospital and have indicated in parentheses the equivalent percentage of all the patients requiring operation. The same presentation has been made for patients operated on within seven days of admission to the hospital. From these figures it appears that upward of 60 per cent of the patients requiring mastoidectomy in any year of this period have had acute mastoiditis on admission to the hospital. This observation becomes of particular importance when one attempts to judge the measure of success achieved by medical treatment.

In tables 6 and 7 the four larger groups of cases in which a bacteriologic diagnosis was made are arranged to show the presence or absence of early drainage of the middle ear by paracentesis of the tympanic membrane. Those cases in which paracentesis was done later than the seventh day of disease have been included among the group in which the tympanic membrane ruptured spontaneously. From these figures it appears that 31 per cent of the patients requiring mastoidectomy had paracentesis of the tympanic membrane during the first week of disease, whereas 68 per cent of the patients who did not require mastoidectomy had similar treatment. This distinction is most striking in the

group in which otitis was due to Pneumococcus type III. In this group 21 per cent of the patients requiring mastoidectomy had early paracentesis of the tympanic membrane, whereas 90 per cent of the patients who recovered without mastoidectomy were so treated. By inference it

TABLE 6.—*Association of Paracentesis of the Tympanic Membrane with the Progress of Acute Suppurative Otitis Media: Cases Requiring Mastoidectomy* *

| Type of Infection | 1935 | 1936 | 1937 | 1938 | 1939 | Total |
|---|---|---|---|---|---|---|
| Cases in Which Paracentesis Was Done During the First Week of Disease | | | | | | |
| Str. haemolyticus beta | 13 | 13 | 18 | 13 | 9 | 66 |
| Pneumococcus type III | 3 | 3 | 0 | 4 | 1 | 11 |
| Pneumococcus (other types) | 1 | 0 | 0 | 3 | 0 | 4 |
| Staph. pyogenes | 0 | 1 | 0 | 0 | 0 | 1 |
| Total | | | | | | 82 |
| Cases in Which There Was Spontaneous Rupture of the Tympanic Membrane or Paracentesis After the First Week of Disease * | | | | | | |
| Str. haemolyticus beta | 28 | 20 | 20 | 28 | 27 | 123 |
| Pneumococcus type III | 10 | 2 | 9 | 11 | 8 | 40 |
| Pneumococcus (other types) | 2 | 2 | 6 | 3 | 1 | 14 |
| Staph. pyogenes | 0 | 0 | 2 | 4 | 1 | 7 |
| Total | | | | | | 184 |

* Only cases in which the bacteriologic origin of the otitis is known are referred to in this table.

TABLE 7.—*Association of Paracentesis of the Tympanic Membrane with the Progress of Acute Suppurative Otitis Media: Cases Not Requiring Mastoidectomy* *

| Type of Infection | 1935 | 1936 | 1937 | 1938 | 1939 | Total |
|---|---|---|---|---|---|---|
| Cases in Which Paracentesis Was Done During the First Week of Disease | | | | | | |
| Str. haemolyticus beta | 10 | 13 | 16 | 17 | 15 | 71 |
| Pneumococcus type III | 2 | 2 | 4 | 3 | 7 | 18 |
| Pneumococcus (other types) | 12 | 7 | 2 | 9 | 9 | 39 |
| Staph. pyogenes | 5 | 5 | 2 | 5 | 5 | 22 |
| Total | | | | | | 150 |
| Cases in Which There Was Spontaneous Rupture of the Tympanic Membrane or Paracentesis After the First Week of Disease * | | | | | | |
| Str. haemolyticus beta | 6 | 5 | 9 | 13 | 16 | 49 |
| Pneumococcus type III | 0 | 0 | 0 | 0 | 2 | 2 |
| Pneumococcus (other types) | 0 | 1 | 1 | 2 | 6 | 10 |
| Staph. pyogenes | 0 | 0 | 0 | 5 | 5 | 10 |
| Total | | | | | | 71 |

* Only cases in which the bacteriologic origin of the otitis is known are referred to in this table.

may be assumed that early medical care was provided in larger degree for patients not requiring mastoidectomy than for those who suffered a mastoid complication.

In 1938 and 1939 the percentage of patients without early drainage from the middle ear who avoided mastoidectomy was increased over that of previous years. This may be attributed to the use of chemo-

therapy, inasmuch as the majority of these particular patients received either sulfanilamide or sulfapyridine (2-[paraaminobenzenesulfonamide]-pyridine).

In table 8 the average number of days spent in the hospital by patients who did not require mastoidectomy is presented without reference to the bacteriologic diagnosis. The average number of postoperative days for patients on whom mastoidectomy was performed is similarly presented. In the lower half of the table such figures are included for patients who received chemotherapy. The number of patients receiving chemotherapy is indicated in parentheses.

In 1937 relatively few patients were treated with sulfanilamide, and the dosages were conservative. In 1938 sulfanilamide was given to 30 per cent of the patients admitted to the hospital. As a rule, it was given

TABLE 8.—*Hospitalization as Related to Treatment*

| Group | 1935 | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|---|
| **Average Number of Hospital Days Required for the Treatment of Acute Suppurative Otitis Media** | | | | | |
| Patients not requiring mastoidectomy | 9.8 | 9.3 | 7.7 | 9.4 | 10.5 |
| Patients in hospital after mastoidectomy | 18.3 | 16.6 | 20.0 | 16.2 | 19.0 |
| **Average Number of Hospital Days Required for Treatment by Chemotherapy** | | | | | |
| | | | 1937 | 1938 | 1939 |
| Patients not requiring mastoidectomy | | | 13.1 (10 patients) | 9.5 (17 patients) | 11.7 (60 patients) |
| Patients in hospital after mastoidectomy | | | 32.0* (15 patients) | 16.8 (28 patients) | 19.6 (45 patients) |
| | | | 20.75 (12 patients) | | |

* Three patients had unusually long hospitalization.

to those suffering from the more severe infections with Str. haemolyticus beta. In 1939 sulfanilamide or sulfapyridine was given to more than 75 per cent of the patients admitted to the hospital. As a rule, the former drug was used when the infection was known to be due to Str. haemolyticus beta and the latter drug when the infection was due to a pneumococcus. In 1938 and 1939 the quantities of these drugs used varied considerably but were controlled by frequent determinations of the concentration in the blood, the white blood count and the clinical progress of the patient.

It appears that the average number of days spent in the hospital by patients for whom chemotherapy was used has been higher than that indicated as the general average for all patients. This requires some explanation, as it does not mean that the progress of these patients was retarded by the use of chemotherapy. In the majority of cases the patients were detained in the hospital until they were completely free from their infection or were discharged from the hospital in much better condition than had previously been considered to be necessary.

Data concerning cases in which the more serious complications of acute suppurative otitis media occurred are compiled in tables 9 to 14. Some of the patients have been treated in the Montreal Neurological

TABLE 9.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Meningitis*

| Year | Age of Patient, Years | Organism | Result |
|---|---|---|---|
| 1935 | 7 | Str. haemolyticus beta | Death |
| 1935 | 6 | Str. haemolyticus beta | Death |
| 1935 | 23 | Str. haemolyticus beta | Death |
| 1935 | 9 | Str. haemolyticus beta | Death |
| 1935 | 46 | Pneumococcus type III | Death |
| 1935 | 60 | Pneumococcus type III | Death |
| 1935 | 25 | Pneumococcus type III | Death |
| 1935 | 36 | Pneumococcus type IV | Death |
| 1936 | 14 | Str. haemolyticus beta | Death |
| 1936 | 36 | Pneumococcus type III | Death |
| 1937 | 6 | Str. haemolyticus beta | Death |
| 1937 | 5 | Str. haemolyticus beta | Death |
| 1937 | 52 | Pneumococcus type I | Death |
| 1937 | 13 | Str. haemolyticus beta | Recovery |
| 1938 | 49 | Pneumococcus type III | Death |
| 1938 | 15 | Pneumococcus type ? | Death |
| 1938 | 68 | Staph. pyogenes | Death |
| 1938 | 15 | Str. haemolyticus beta | Recovery |
| 1938 | 14 | Str. haemolyticus beta | Recovery |
| 1938 | 11 | No growth | Recovery |
| 1939 | 5 | Str. haemolyticus beta | Recovery |
| 1939 | 30 | Str. haemolyticus beta | Recovery |

TABLE 10.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Thrombosis of the Lateral Sinus*

| Year | Age of Patient, Years | Organism | Result |
|---|---|---|---|
| 1935 | 21 | Str. haemolyticus beta | Recovery |
| 1935 | 6 | Str. haemolyticus beta; Pneumococcus type IV (Associated with otitic hydrocephalus, petrositis and septicemia [Str. haemolyticus beta]) | Recovery |
| 1935 | 25 | Pneumococcus type III (Associated with meningitis) | Death |
| 1936 | 4 | Str. haemolyticus beta | Recovery |
| 1937 | 6 | Str. haemolyticus beta | Recovery |
| 1938 | 42 | Pneumococcus type III (Associated with cerebellar abscess) | Death |
| 1938 | 40 | Str. haemolyticus beta | Recovery |
| 1938 | 8 | Str. haemolyticus beta (Associated with otitic hydrocephalus, petrositis and septicemia) | Recovery |
| 1938 | 22 | Pneumococcus type III (Associated with pneumonia type III) | Recovery |
| 1938 | 49 | Pneumococcus type III (Associated with meningitis) | Death |
| 1939 | No cases | | |

Institute or in collaboration with the staff of that institution. The neurologists and neurosurgeons have contributed much to the successful recovery of patients with intracranial complications.

Probably the most dramatic progress made in the treatment of acute suppurative otitis media is recorded in table 9. Prior to the advent of

TABLE 11.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Septicemia (Positive Blood Cultures) or by Acute Serous Labyrinthitis*

| Year | Age of Patient, Years | Organism | Result |
|---|---|---|---|
| | | **Septicemia** | |
| 1935 | 6* | Str. haemolyticus beta | Recovery |
| 1936 | 4* | Str. haemolyticus beta | Recovery |
| 1937 | 10 | Str. haemolyticus beta | Recovery |
| 1937 | 11 | Str. haemolyticus beta | Recovery |
| 1938 | 8* | Str. haemolyticus beta | Recovery |
| 1939 | No cases | | |
| | | **Acute Serous Labyrinthitis** | |
| 1935 | 18 | Str. haemolyticus beta | Recovery |
| 1937 | 53 | Pneumococcus type III | Recovery |
| 1938 | 12 | Pneumococcus type I | Recovery |
| 1939 | 16 | Diphtheroids † | Recovery |

* In these cases the conditions were associated with thrombosis of the lateral sinus.
† In this case the infection followed a fracture of the temporal bone.

TABLE 12.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Brain Abscess or by Otitic Hydrocephalus*

| Year | Age of Patient, Years | Organism | Result |
|---|---|---|---|
| | | **Brain Abscess** | |
| 1938 | 42 | Pneumococcus type III (Cerebellar lobe; associated with thrombosis of the lateral sinus) | Death |
| 1938 | 15 | Pneumococcus type ? (Cerebellar lobe; associated with meningitis) | Death |
| 1939 | 42 | Str. haemolyticus beta (Temporosphenoidal lobe) | Recovery |
| | | **Otitic Hydrocephalus** | |
| 1935* | 6 | Str. haemolyticus beta; Pneumococcus type IV | Recovery |
| 1938* | 8 | Str. haemolyticus beta | Recovery |

* Associated with sinus thrombosis and petrositis.

TABLE 13.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Petrositis or by Facial Paralysis*

| Year | Age of Patient, Years | Organism | Result |
|---|---|---|---|
| | | **Petrositis** | |
| 1935 | 6 | Str. haemolyticus beta (Noted with otitic hydrocephalus) | Recovery |
| 1936 | 17 | Str. haemolyticus beta | Recovery |
| 1937 | 30 | Pneumococcus type III | Recovery |
| 1938 | 8 | Str. haemolyticus beta (Noted with otitic hydrocephalus) | Recovery |
| | | **Facial Paralysis** | |
| 1935 | 1 | No growth | Improvement |
| 1937 | 39 | Micrococcus | Improvement |
| 1938 | 49 | Pneumococcus type ? | Improvement |
| 1938 | 60 | Pneumococcus type III | Improvement |
| 1939 | 39 | Str. haemolyticus beta | Recovery |
| 1939 | 6 | Pneumococcus type I | Recovery |

sulfanilamide, patients suffering from bacterial meningitis of otitic origin rarely recovered. In 1937 1 patient with meningitis due to the beta type of hemolytic streptococcus recovered. In 1938 3 patients out of

TABLE 14.—*Data on Cases of Acute Suppurative Otitis Media Complicated by Abscess*

| Year | Age of Patient, Years | Organism | | Result |
|---|---|---|---|---|
| | | **Bezold's Abscess** | | |
| 1935 | 49 | Str. haemolyticus beta | | Recovery |
| 1936 | 48 | Pneumococcus type III | | Recovery |
| 1937 | 24 | Pneumococcus type III | | Recovery |
| | | **Retropharyngeal Abscess** | | |
| 1935 | 1 | Str. haemolyticus beta | | Recovery |
| 1936 | ½ | No culture | | Recovery |
| 1936 | 15 | Str. haemolyticus beta | | Recovery |
| 1937 | 10 | Str. haemolyticus beta | | Recovery |
| | | **Abscess of the Temporomandibular Joint** | | |
| 1935 | 8 | Str. haemolyticus beta | | Improvement |
| | | **Subperiosteal Abscess of Mastoid** | | |
| | | | No. of Cases | |
| 1935 | .. | Pneumococcus type III | 2 | |
| 1936 | .. | Pneumococcus type III | 1 | |
| 1936 | .. | No culture | 1 | Recovery after mastoidectomy in all cases |
| 1937 | .. | Str. haemolyticus beta | 1 | |
| 1938 | .. | Str. haemolyticus beta | 6 | |
| 1938 | .. | Pneumococcus type III | 1 | |
| 1939 | .. | Str. haemolyticus beta | 3 | |

TABLE 15.—*Deaths from Complications of Acute Suppurative Otitis Media*

| Year | Age of Patient, Years | Organism | Cause |
|---|---|---|---|
| 1935 | 7 | Str. haemolyticus beta | Meningitis |
| 1935 | 6 | Str. haemolyticus beta | Meningitis |
| 1935 | 9 | Str. haemolyticus beta | Meningitis |
| 1935 | 23 | Str. haemolyticus beta | Meningitis |
| 1935 | 46 | Pneumococcus type III | Meningitis |
| 1935 | 60 | Pneumococcus type III | Meningitis |
| 1935 | 25 | Pneumococcus type III | Meningitis |
| 1935 | 36 | Pneumococcus type IV | Meningitis |
| 1936 | 14 | Str. haemolyticus beta | Meningitis |
| 1936 | 36 | Pneumococcus type III | Meningitis |
| 1936 | 62 | Pneumococcus type I | Pneumonia |
| 1937 | 6 | Str. haemolyticus beta | Meningitis |
| 1937 | 5 | Str. haemolyticus beta | Meningitis |
| 1937 | 52 | Pneumococcus type I | Meningitis |
| 1938 | 49 | Pneumococcus type III | Meningitis |
| 1938 | 42 | Pneumococcus type III | Cerebellar abscess |
| 1938 | 15 | Pneumococcus type ? | Meningitis and cerebellar abscess |
| 1938 | 68 | Staph. pyogenes | Meningitis |
| 1939 | None | | |

6 recovered. In 1939 the incidence of the complication was reduced to 2, and in both cases the patients recovered. The only organism recognized in these cases was the beta hemolytic streptococcus. The patients received sulfanilamide or one of its derivatives. There is no hesitation

in attributing their recovery to chemotherapy, although they were also treated by mastoidectomy and frequent lumbar punctures.

Not only has the prognosis of otitic meningitis become more promising, but the incidence of complications in general has been reduced, as a sequel to the use of chemotherapy.

### ACUTE SUPPURATIVE OTITIS MEDIA CAUSED BY PNEUMOCOCCUS TYPE III

During the five year period under review 71 cases of acute otitis media in which the infecting organism was Pneumococcus type III have been encountered. It is not the purpose of this study to describe in detail the characteristics of this disease. Such a description has recently appeared, by Maybaum and Druss.[1] There are, however, certain facts in these cases that may be considered to have definitely affected the results of treatment.

That this is the most treacherous type of otitis media is evidenced by the fact that, although it was found in fewer than 10 per cent of the cases reviewed, it accounted for one third of the deaths and 30 per cent of all intracranial complications.

During the first four years of this study 80 per cent of patients with otitis caused by Pneumococcus type III required mastoidectomy. In 1939 only 50 per cent required mastoidectomy. The 50 per cent who did not have been well for at least six months. One patient who was treated by a simple mastoidectomy in December 1939 had what was considered to be a new infection in April 1940, and died with meningitis. The organism found in the culture from the ear and in that from the cerebrospinal fluid was Pneumococcus type XXXII.

An investigation of the onset of acute suppurative otitis media due to Pneumococcus type III has revealed that in 45 cases it followed a simple infection of the upper respiratory system. In 5 cases the onset was associated with lobar pneumonia. In 2 of these cases the pneumonia was definitely due to Pneumococcus type III. In 2 cases the otitic infection followed postoperative hemorrhages at the sites of tonsillectomy and adenoidectomy. The patients were children aged 3 and 6 years, in 1 of whom the infection was bilateral. Both recovered without mastoidectomy. In 1 patient, a man aged 49, the infection of the ear occurred after a postnasal pack had been used to control epistaxis. In 1 man, aged 57 years, the infection developed after eustachian obstruction associated with flying. Aural pain as the initial symptom was reported in only 8 cases. Aural discharge was reported as the initial symptom in 7 cases. Dizziness occurred at the onset in 1 case and tinnitus in 4 cases.

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1. Maybaum, J. L., and Druss, J. G.: Otitic Infections Due to the Pneumococcus Type III, Arch. Otolaryng. **30**:21 (July) 1939.

In table 16 I have divided the cases into two groups, one in which the patients are under the age of 21 years and a second in which the patients are over the age of 21 years. Whether or not mastoidectomy was required is indicated. The ages of the younger patients are presented. The percentage of patients in these two age periods who

TABLE 16.—*Data on Cases of Acute Suppurative Otitis Media Due to Pneumococcus Type III*

| Year | Number of Patients Requiring Mastoidectomy | Age of Patients | Number of Patients Not Requiring Mastoidectomy | Age of Patients | Percentage of Patients Not Requiring Mastoidectomy | |
|---|---|---|---|---|---|---|
| **Patients Under 21 Years of Age** | | | | | | |
| 1935 | 1 | 11 mo. | 1 | 7½ mo. | 50 | 57 |
| 1936 | None | | 2 | 4 and 7 yr. | 100 | |
| 1937 | 1 | 7 yr. | 1 | 7 yr. | 50 | |
| 1938 | 1 | 5 yr. | None | | 0 | |
| 1939 | 2 | 13 and 17 yr. | 6 | 3½, 6, 3, 9, 6½, and 3 yr. | 75 | |
| **Patients Over 21 Years of Age** | | | | | | |
| 1935 | 12 | | 1 | | 7.7 | 15.2 |
| 1936 | 5 | | None | | 0 | |
| 1937 | 8 | | 3 | | 27.2 | |
| 1938 | 14 | | 3 | | 17.6 | |
| 1939 | 7 | | 3 | | 30 | |

TABLE 17.—*Average Number of Days from the Onset of Aural Symptoms to Hospitalization in Cases of Acute Suppurative Otitis Media Caused by Pneumococcus Type III*

| Year | Average Number of Days for Patients Not Requiring Mastoidectomy | Average Number of Days for Patients Requiring Mastoidectomy |
|---|---|---|
| 1935 | 4.5 | 38 |
| 1936 | 2 | 10.4 |
| 1937 | 3.75 | 36 |
| 1938 | 4.6 | 26.5 |
| 1939 | 6 | 25.4 |

did not require mastoidectomy is indicated. From this study it appears that children have a much better prognosis in this disease than have adults. During the first four years in review 57 per cent of the younger patients recovered without mastoidectomy, as compared to 15.2 per cent of the older ones. In 1939 these percentages rose to 75 and 30, respectively. Another important fact is that, with the exception of subperiosteal abscess, no complications occurred in the younger patients. If it is assumed that the apparent improvement in 1939 was due to

the use of sulfapyridine, it must be borne in mind that practically as good results were recorded in 1936 and 1937 for the younger and older patients, respectively. None of those patients were treated by chemotherapy.

In table 17 a comparison of the average number of days from the onset of aural symptoms to hospitalization for patients requiring or not requiring mastoidectomy illustrates the urgent need of early treatment in cases of acute suppurative otitis media due to Pneumococcus type III.

Before 1939 two plans of treatment for this type of otitis media were followed in the Royal Victoria Hospital. One plan, strongly advocated by Dr. H. S. Birkett, entailed mastoidectomy as soon as the bacteriologic diagnosis had been made. The mastoid cavity was packed with gauze saturated with diluted solution of sodium hypochlorite and was kept moist by frequent irrigations with the same solution. Healing was thus retarded until cultures from the wound were free from pneumococci of type III on three consecutive occasions. Twelve patients in this series were treated in this way, and all eventually recovered. The second plan demanded mastoidectomy only in the event of definite mastoiditis. The cavity was packed with some form of dry gauze, and healing was not interrupted. Twenty-seven patients were treated in this way, and 3 died. Three patients who were moribund on admission have not been considered from the standpoint of treatment.

In 1939 sulfapyridine was given to 17 of the 18 patients treated. The amount of the drug was determined by previously mentioned controls. Mastoidectomy was undertaken only when clinical or roentgenographic evidence supported the diagnosis of progressive mastoiditis. In 50 per cent of the cases mastoidectomy was necessary. Postoperative treatment in 2 cases included the use of diluted solution of sodium hypochlorite, while in the remaining 7 cases plan 2 was followed as outlined in the preceding paragraph. No further complications occurred in the patients [2] who were operated on, and those patients who recovered without operation remained well for at least six months.

It is interesting to note that in 1939 the patients who avoided mastoidectomy were treated early in the course of their disease. This means that the use of sulfapyridine has not changed the pattern of table 17. However, among those who avoided mastoidectomy in 1939 were 3 adults, whose average period of hospitalization amounted to ten days. Each of these patients had paracentesis of the tympanic membrane

2. In 1 patient who had a simple mastoidectomy in December 1939, what was considered a new infection developed in April 1940, and the patient died of meningitis. The organism found in the culture from the ear and in that from the cerebrospinal fluid was the pneumococcus type XXXII.

before the fifth day of disease. It is difficult to assume the measure of success which might have been experienced in these cases without sulfapyridine. The results of treatment in 1939 have been the best during this period of investigation. Before 1939 about one third of those patients who required mastoidectomy also suffered from additional complications. It is significant that in 1939 no complication other than mastoiditis occurred.

For the purpose of emphasizing in retrospect the importance of early diagnosis and treatment of cases of acute suppurative otitis media due to Pneumococcus type III, brief histories of 6 fatal cases are reported:

REPORT OF CASES

CASE 1.—1935. A woman aged 46 complained of dizziness and of tinnitus in the affected ear for three weeks before admission to the medical ward. It was thought that her symptoms were referable to hypochromic anemia and general debility, from which she had suffered for some time. After two weeks' hospitalization she was found to have roentgenographic evidence of mastoiditis, although the associated ear drum was relatively normal. There was no definite history of aural discharge. Audiograms and vestibular tests were not made. A simple mastoidectomy was performed five weeks from the onset of symptoms. Considerable destruction of the intercellular walls was found. The mastoid cavity was packed with plain gauze. The postoperative condition was good for eleven days, when signs and symptoms of meningitis suddenly developed and the patient died two days later. Histologic sections of the temporal bone showed the labyrinth to have been destroyed and revealed a progressive extension of disease from the mastoid area to the meninges. The pathologist expressed the opinion that the labyrinth had been destroyed early in the course of the disease.

CASE 2.—1935. A woman aged 60 complained of pain and discharge from the right ear for two weeks before admission to the hospital. This was preceded by grip of two weeks' duration. The ear drum had ruptured spontaneously thirty-six hours after the onset of pain. One week before admission to the hospital there had been considerable discharge from the ear, associated with nasal obstruction and profuse purulent nasal discharge.

On admission to the hospital the left ear drum was normal. The right ear drum was perforated and the canal was filled with thick, white discharge. The soft tissues in the left nostril were congested.

One day after admission to the hospital attacks of dizziness were experienced. On the third day after admission simple mastoidectomy was performed. The cavity was packed with iodoform treated gauze. Four days later the patient had a definite elevation of temperature to 102 F., complained of headache and was restless. Thirteen days after operation she had more definite signs of meningitis. The cerebrospinal fluid contained 4,500 cells, and pneumococci of type III were present in large numbers.

The patient died eighteen days after mastoidectomy, of meningitis.

No postmortem examination was made.

CASE 3.—1935. A woman aged 25 experienced pain in her right ear on April 7. On the same day the ear drum ruptured spontaneously. The perforation was small, and paracentesis was done. On April 10 a second paracentesis was performed, followed by a third on April 13. The patient was eight months pregnant and was

admitted to the maternity hospital on April 16. A healthy child was born on the following day. Cultures from the ear showed the presence of Pneumococcus type III. A simple mastoidectomy was done on April 21.

On April 24 a diagnosis of lateral sinus thrombosis was made, and the right internal jugular vein was ligated.

On May 14 symptoms of petrositis were present, with Gradenigo's syndrome, and a radical mastoidectomy was done, with extensive removal of the petrous bone. Symptoms and signs of meningitis followed this operation, and the patient was transferred to the Neurological Institute, where she died seventy-five days from the onset of her infection.

CASE 4.—1936. A man aged 35 gave a history of cold which lasted for three days, when pain occurred in the left ear. Two days later he was seen by an otologist. The left drum was bulging. A paracentesis was done. Two days later he was admitted to the hospital in a semicomatose condition, and a simple mastoidectomy was done on the affected side. At operation the mastoid was found to be destroyed to a considerable extent. A diagnosis of meningitis was made, and the patient was immediately transferred to the Montreal Neurological Institute. The day after the mastoidectomy he died. The cerebrospinal fluid was heavily infected with pneumococci of type III.

No postmortem examination was made.

CASE 5.—1938. A man aged 42 was referred to the Montreal Neurological Institute one day after a simple mastoidectomy, with a diagnosis of acute mastoiditis, thrombosis of the lateral sinus and cerebellar abscess.

He had complained of uncomfortable sensations in the right ear for three months. These were associated with impairment of hearing in the affected ear. For six weeks before operation he had pain in the right side of his neck below the mastoid process and stiffness of the neck. For one week there had been definite weakness of the right arm and difficulty in articulation. He gave a history of vomiting three days before operation.

On examination the canal of the right ear was found to be occluded by swelling of the posterior wall. The left ear drum was perforated, and the history disclosed that the patient had had a chronic infection on that side for a number of years. Mastoidectomy revealed considerable destruction of the mastoid process and thrombosis of the lateral sinus.

On his admission to the Montreal Neurological Institute, bilateral occipital trephination and ventriculography gave evidence of a cerebellar neoplasm or abscess, but this was not confirmed during the subsequent craniotomy and exploration, which took place on the following day. Three days after admission to the Institute the patient died. Section of the brain after autopsy revealed the presence of a large biloculated abscess in the right hemisphere of the cerebellum.

CASE 6.—1938. A woman aged 49 was admitted to the hospital in a state of coma. The history, as given by her family, showed that pain had developed in the right ear eleven days before admission to the hospital and that on the eighth day of her disease paracentesis was done on the right ear drum. Six days before admission pain developed in the left ear. This ear had not been interfered with. The patient had severe frontal headache for three days and became comatose a few hours before admission to the hospital.

On examination, the right aural canal was filled with discharge, and the right drum was inflamed and swollen. The left ear drum was bulging. As soon as possible after admission, a simple mastoidectomy was performed on the right side.

The lateral sinus was found to be thrombosed. A paracentesis of the left ear drum was done. A lumbar puncture confirmed the diagnosis of meningitis. Pneumococci of type III were present in the spinal fluid.

The patient died a few hours after operation.

## SUMMARY

A review of the cases of 754 patients with acute suppurative otitis media treated at the Royal Victoria Hospital, Montreal, Canada, and Montreal Neurological Institute, in the period from 1935 to 1939 inclusive, is herewith submitted. Only patients admitted to the hospital have been included in the study. Various influences affecting the results of treatment have been discussed, and tables have been prepared to show:

The results of bacteriologic investigations of acute suppurative otitis media.

The age incidence for bacteriologic groups.

The comparative numbers of cases in which mastoidectomy was required in various bacteriologic groups.

The percentage of patients admitted to the hospital whose otitis was already complicated by acute mastoiditis.

A comparative study of the results of treatment associated with early and late paracentesis of the tympanic membrane.

The average number of days spent in the hospital by patients not requiring mastoidectomy and the average number of postoperative days spent in the hospital by patients requiring mastoidectomy, with a comparison of similar figures for patients receiving chemotherapy.

A review of the more serious complications occurring in this five year period.

The influence of age and of early treatment on infections caused by Pneumococcus type III.

The effect of sulfapyridine on pneumococcic forms of this disease.

A synopsis of 6 fatal cases of suppurative otitis media due to Pneumococcus type III is given, showing the need for early diagnosis and treatment.

When compiling the data for this paper, I overlooked the following cases of acute suppurative otitis media:

In 1935 a boy aged 8 years died five weeks after the onset of disease from bilateral mastoiditis and meningitis due to Streptococcus haemolyticus.

In 1936 a man aged 46 years, with mastoiditis due to Pneumococcus type IV, died fifteen weeks after the onset of disease from lateral sinus thrombosis and meningitis.

In 1936 a girl aged 16 months died five weeks after the onset of disease from meningitis due to Haemophilus influenzae.

Dr. E. C. Campbell, of Woodsville, N. H., assisted in assembling case records of this study.

# EXTERNAL OTITIS

## A STUDY OF THE COMPARATIVE MERITS OF MEDICAL AND ROENTGEN THERAPY

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The care and treatment of infections of the external auditory canal are often a difficult problem in the work of the otologist and the dermatologist. It is our aim to review a number of cases in which treatment was medical, and others in which roentgen radiation was used in order to determine the efficacy of each modality in the treatment of these conditions. The specific therapy used for acute infections of the external canal makes little difference in the great majority of cases, for the condition is usually more or less self limited. On the other hand, the chronic and recurrent infections in this region offer a serious therapeutic challenge.

### CLASSIFICATION

Because of the overlapping of various types of external otitis and its symptoms as well as the gradual merging of one type of inflammation into another, the nomenclature presents somewhat of a problem. A review of the recent literature on this subject has failed to produce any practical classification. We find the following classification, a modification by Brown,[1] to be the most serviceable for the purposes of this report:

Acute:
- Otitis externa circumscripta (acute furuncular)
- Otitis externa diffusa (acute generalized furuncular)
- Otitis externa haemorrhagica (herpes or bleb formation of canal)
- Erysipelas
- Impetigo, intertrigo and fissures

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1. Brown, L. G.: Inflammation of the External Ear and External Auditory Meatus, in Fowler, E. P.: Medicine of the Ear, New York, Thomas Nelson & Sons, 1939.

Subacute: Eczematous otitis externa
(diffuse edematoid, due to local allergic bacterial reaction)
Otitis externa circumscripta
Otitis externa diffusa

Chronic: Eczema
(true seborrheic, allergic or other systemic eczemas; neurodermatitis)
Otitis externa mycotica
(true fungus or yeast infections)
Perichondritis

Otitis externa secondary to purulent otitis media
(may resemble any of the above types, acute, subacute and chronic)

Many of the descriptive terms used here are self explanatory. Acute furuncles of the external auditory canal begin in the pilosebaceous follicles and are typically due to Staphylococcus aureus or Staphylococcus albus, although occasionally Pneumococcus may be found. Otitis externa diffusa gives signs and symptoms much like those of a furuncle but is generally more severe and involves the external canal along more or less of its entire length. Otitis externa haemorrhagica presents the not uncommonly seen purple or clear blebs in the ear canal, close to the drum or actually involving the drum, such as are seen in patients suffering from virus infections of the influenzal type, herpes zoster (Hunt's syndrome) or other vesicle-forming inflammations. Erysipelas, impetigo, intertrigo and fissures of the auditory canal need no further discussion, as they resemble the same conditions commonly seen in other portions of the body, and the first three are diagnosed by more typical lesions occurring elsewhere on the affected person.

Under the grouping of subacute infections of the external auditory canal, eczematous otitis externa is suggested by Brown [1] to describe a diffuse edematoid reaction which occurs when tissue cells of the skin become sensitized "to any of the infecting organisms or their antigens." This condition tends to be subacute but may persist and become chronic.

True eczema of the external canal on an allergic or seborrheic basis is not uncommon and in many cases is bilateral. A localized neurodermatitis or lichenification of the meatal canal is frequently seen in patients who improvise home-made instruments, hairpins, toothpicks, cotton swabs or long finger nails, to relieve a low grade pruritis in this canal, the use of which only causes further pathologic changes, with increased itching. The more commonly found fungus infections of the ear are those caused by Aspergillus of the niger, flavus and nidulans types and by Pityrosporum. In the beginning these cause little in the way of symptoms aside from filling of the auditory canal with their characteristic debris but render the canal more vulnerable to secondary

infection by bacterial invaders, especially if it is traumatized by scratching. Perichondritis sometimes occurs in deep chronic infection of the canal wall. It is seen in most instances after severe furuncular infections, in long-standing infections of the canal secondary to chronic otorrheas or in secondary infection of traumatic hematomas. Involvement of the cartilage by the infection may produce serious deformity.

Infections of the external canal secondary to purulent otitis media may take on the appearance and present the symptoms of any of the bacterial infections mentioned in the acute, subacute or chronic groups of the preceding classification. Their claim to special mention in a group of their own lies in their tendency toward chronicity and recurrence, because of the persistently irritating effect of purulent matter from the middle ear on the epithelium of the canal wall.

As stated previously, it is extremely common to have one form of infection merge into another. Otomycotic infections of the canal following fresh or salt water bathing frequently become furuncular in type. It is bathing which makes for the great increase of cases of this type in our clinic in the summer. The water helps the growth of the fungi, and the canals are often traumatized in an effort to remove the water or, as mentioned previously, in an effort to relieve the itching. Acute furuncular infections may, after a few weeks, become eczematous in character, with the formation of local antigen response. In attempting to analyze the relative merits of two modes of therapy in a dozen or more forms of a single disease, which are often interchangeable, the otologist has a problem which becomes increasingly complex. On the other hand, it is readily seen that each of the clinical forms of infection of the ear canal tends to fit into an acute, a subacute and a chronic group.

We have therefore found it practical from a therapeutic and prognostic point of view to discuss all cases primarily from a consideration of the duration of symptoms when the patient was first seen by us. By arbitrarily designating those infections seen in the first week of illness as acute, those seen before the third week as subacute and those of longer duration as chronic, we have noted certain distinct advantages of roentgen therapy in the treatment of chronic forms of otitis externa and of medical treatment in the care of acute infections.

## BACTERIOLOGY

When this study was first undertaken it was hoped that something of prognostic significance could be drawn from a bacteriologic survey of the cases considered. However, that has not been possible.

McBurney and Searcy [2] emphasized the importance of fungi as the causative agents in external otitis. Greaves,[3] in analyzing his 75 cases, failed to demonstrate a single instance of fungus infection. Other workers have held forth in favor of the theory that streptococcus and staphylococcus organisms are the primary invaders in external otitis. Williams and his associates [4] stated that in their thorough bacteriologic study of 34 cases they "were unable to establish definitely in any case that the dermatitis was primarily on a bacteriological, fungal or allergic basis."

In our own series of 200 cases, cultures commonly showed more than one organism to be present in each case. They were identified in the following order of frequency as: Staphylococcus aureus, Staphylococcus albus, diphtheroids, Bacillus pyocyaneus and micrococci. Only 8 cases of aspergillus infection were reported. Unfortunately the exact statistics cannot be given, as in the majority of acute cases studied in the early years of this review cultures were not taken. However, in the more significant group of chronic therapy-resistant infections, a predominating organism was not present.

A bacteriologic study of 25 normal ear canals was done by one of us (H.S.F.). The bacteria cultured and their frequency of occurrence are listed here: (Many cultures grew more than one organism.)

| | |
|---|---|
| Staphylococcus albus | 11 |
| Diphtheroids | 7 |
| Micrococci (catarrhalis group) | 5 |
| Staphylococcus aureus | 2 |
| Bacillus subtilis | 1 |
| Streptococcus haemolyticus | 1 |
| Streptococcus viridans | 1 |

With the exception of B. pyocyaneus, which is a notorious saprophyte, these are the same as the group found in cultures from diseased external auditory canals. Cultures for the fungi in normal ears were not made.

### MEDICAL TREATMENT

One hundred cases of external otitis having adequate follow up, selected in sequence from the files of the Ear, Nose and Throat Outpatient Department of the Presbyterian Hospital (1935 to 1938) are

2. McBurney, R., and Searcy, H. B.: Otomycosis: Investigation of Effective Fungicidal Agents in Treatment, Ann. Otol., Rhin. & Laryng. **45**:988-1008 (Dec.) 1936.

3. Greaves, F. C.: Phenylmercuric Nitrate in the Treatment of Otitis Externa and the Dermatophytoses, U. S. Nav. M. Bull. **34**:527-532 (Oct.) 1936.

4. Williams, H. L.; Montgomery, H., and Powell, W. N.: Dermatitis of the Ear, J. A. M. A. **113**:641-645 (Aug. 19) 1939.

analyzed in table 1. The patients were treated with the usual clinic medical methods described in subsequent paragraphs and did not receive any roentgen radiation.

In this series there were 68 females and 32 males; this shows the usual preponderant susceptibility of females to this type of infection. Whether this susceptibility is due to the fact that women are more likely than men to get water in their ears when they wash their hair is a question. In 68 cases the duration of symptoms was less than one week. The great majority of the acute infections occurred in the summer, and many of these were the direct result of bathing in salt water or in swimming pools. The therapeutic results in these acute infections were universally good, since 71 per cent cleared in less than one week and in only 13 per cent was one month required for complete relief of the pruritis and pain, which, together with objective observations, was considered the criterion for cure.

TABLE 1.—*One Hundred Cases of External Otitis in Which Medical Treatment Was Used*

| Duration of Symptoms at First Examination | Number of Cases | Clinical Cures, % | | | | Recurrences, % | Failures, % |
|---|---|---|---|---|---|---|---|
| | | After 1 Week | After 2 Weeks | After 1 Mo. | After 6 Mo. | | |
| Acute group (symptoms less than 1 week) | 68 | 71 | 16 | 13 | .. | 3 | .. |
| Subacute group (symptoms of 1 week to 3 months) | 21 | 36 | 24 | 24 | 5 | 11 | 9 |
| Chronic group * (symptoms for 3 months to 3 years) | 11 | .. | 9 | .. | 19 | 9 | 72 |

* Includes 2 cases in which the external condition was secondary to acute purulent otitis media and 5 in which it was secondary to chronic purulent otitis media.

In the subacute group, only 36 per cent of the conditions cleared in less than one week, and there were failures in 2 cases, which represented 9 per cent of the total.

There were 11 infections of over three months' duration. In this small chronic group medical therapy failed to produce a cure in 72 per cent, and in 19 per cent a cure took between one and six months. It must be borne in mind that certain patients with subacute involvement were referred for roentgen therapy and were thus eliminated from the medical series.

Williams and his associates [4] stressed the self-limited nature of acute external otitis in most cases when they pointed out that "careful attention to cleansing the external auditory canal is a factor of primary importance in most instances. The selection of drugs for treatment is of distinctly secondary importance." Edmund Prince Fowler Jr., working with W. Neidlinger in the Vanderbilt Clinic, treated 14 patients with acute infection by superficially cleansing the affected ear canal with dry cotton, without resorting to drugs or salves, and reported 13 cures

occurring in an average time of four days. The 1 patient in whom there appeared to be no improvement from therapy was one with bilateral external otitis in whom full blown seborrheic dermatitis of both pinnas and temporal regions later developed.

Although our experience has led us to emphasize the primary importance of simple hygiene in dealing with the external canal, medications were used in all our 100 cases. They included: tampons saturated with a solution of aluminum acetate (0.5 per cent), metacresyl acetate, thymol iodide, 5 per cent phenol in glycerin, 2 per cent tincture of iodine in glycerin, mercurial and coal tar ointments, gentian violet, staphylococcus toxoid and silver nitrate. In cases of aspergillus infection, salicylic acid, thymol iodide and alcohol were used, caution being taken against the use of water in the canal.

Two patients with pyocyaneus infection of the canal were successfully treated with a 2 per cent solution of acetic acid. Four cases of external otitis were encountered in which accompanying otitis media was suspected but could not be diagnosed because of complete stenosis of the external canal. It was believed unfeasible to occlude drainage of the middle ear further by tampons; hence the patients were treated primarily by roentgen therapy and thus eliminated from the medical series. It was also found advantageous to treat several patients with diffuse edematoid lesions of the ear canal by roentgen therapy because of the pain caused by the insertion of tampons in this type of ear canal.

By way of summary it may be stated that even after six months of treatment there were 72 per cent failures and 9 per cent recurrences in the chronic group. It is in the treatment of infections of this group, then, that weakness of pure medical therapy can be seen.

### ROENTGEN THERAPY

The cases of external otitis in which treatment was by roentgen therapy are tabulated in table 2. Because most patients with aural complaints are first seen and usually first treated by the otologists, it is to be expected that series 1 contains most of the cases of acute infection. It is at once obvious that the roentgen series differs from the medical series in that the majority of the cases included were instances either of subacute or of chronic infection. This is further evidenced by the fact that in 82 per cent of the cases in series 2 some medical treatment was given before the patient was sent for roentgen therapy. In brief, this group is largely composed of the cases in which some treatment had been given and the condition found more or less refractory to the usual therapeutic measures. It is cases of this type which present the real problem of treatment and in which roentgen therapy is most beneficial.

It must be emphasized that under ordinary circumstances series 2 might contain no cases of acute otitis, for patients with acute condi-

tions have always been treated by medical means. As a special research project to ascertain the efficacy of roentgen treatment, the Ear, Nose and Throat Department of the Vanderbilt Clinic allowed us to treat a considerable number of patients with external otitis of the acute furuncular and eczematoid types by roentgen therapy alone.

*Technic.*—Although modifications were made to suit each individual case, the approximate technic was as follows:

The factors used were: 130 kilovolts; 4 milliamperes; 3 mm. of aluminum filter; 10 inch (25.4 cm.) distance; circular field 3 to 5 cm. in diameter directly over the external auditory canal.

Dosage was varied in accordance with the severity and acuteness of the symptoms, from 30 roentgen (r) for the most acute to 100 r for the more chronic conditions. In most instances, the acutely inflamed

TABLE 2.—*One Hundred* Cases of External Otitis in Which Roentgen Therapy Was Used*

| Duration of Symptoms at First Examination | Number of Cases | Clinical Cures, % | | | | Incompleted Courses of Treatment, % | Mastoidectomies, % | Recurrences, % | Failures, % |
|---|---|---|---|---|---|---|---|---|---|
| | | After 1 Wk. | After 2 Wk. | After 1 mo. | After 6 mo. | | | | |
| Acute group (symptoms less than 1 week) | 27 | 54 | 13 | 16 | .. | 9 | 8 | 4 | .. |
| Subacute group (symptoms of 1 week to 3 months) | 39 | 25 | 9 | 39 | 6 | 7 | 6 | .. | 8 |
| Chronic group† (symptoms for 3 months to 3 years) | 34 | .. | 3 | 23 | 23 | 9 | 6 | 20 | 36 |

* One hundred patients, 75 females and 25 males, from 4 to 75 years of age.

† Includes 3 cases in which the external otitis was secondary to acute purulent otitis media and 9 in which it was secondary to chronic purulent otitis media.

ears were more comfortable when treated every two or three days. The chronic infections were given 75 to 100 r every week for a month; treatments were then withheld for a month and repeated as indicated. As external otitis is essentially a benign condition, it has been our policy not to give a total dose of more than about 1000 r to each ear.

Six patients with acute infections noted some exacerbation of symptoms within the first ten hours, with subsequent relief. Most of the remaining 21, however, experienced considerable relief within twelve hours, often in three or four hours, after the first treatment. This prompt relief without painful tamponade of the swollen external canal we believe to be one of the important advantages of roentgen therapy in acute external otitis. The subjective relief often occurs with very little objective change. It was found that the sooner roentgen radiation was instigated after the onset of pain, the more dramatic was the response.

No other complications of treatment occurred. No patient with subacute or chronic otitis externa ever noted an exacerbation of

symptoms, and in the favorable cases subjective improvement was practically always noted before the third treatment.

As usual, a certain number of outpatients were lost in the follow-up study or voluntarily discontinued treatment before we considered the condition of the ears satisfactory. Of this number, those whose ears were not healed after eight treatments or after a total of 600 r had been given are represented in the column headed "Failures." Those who discontinued treatment for any reason before receiving the aforementioned minimum of radiation are represented in a separate column headed "Incompleted Courses" rather than in that of failures of roentgen therapy.

As can be seen in table 2, there were a considerable number of failures in the subacute and chronic groups. In all cases in which a minimum of eight treatments was given without complete subjective and objective cure in six months, the treatments are classed as failures. In all cases in which there were recurrences within this six month period the treatments are considered failures, but recurrences after six months are classed only as recurrences and are listed in a separate column. Of the recurrences so listed, only 1 was in the acute group and 6 in the chronic group (an incidence of 20 per cent). All of the latter were eczematous lesions, and 4 were bilateral. It is interesting to note that in every case in which there was recurrence following treatment there was a history of repeated attacks before the institution of treatment.

Chronic purulent otitis media was obviously present in 12 cases, the copious discharge acting as a constant source of irritation to the canal. In 3 of these the condition was subacute and in 9 chronic. Of these 12 patients, 6 underwent mastoid operations before the otitis externa was controlled. Patients treated in this way were regarded as showing neither successes nor failures of roentgen therapy. They are represented in table 2 separately, under the heading "Mastoidectomies."

### EXPERIMENTAL SERIES

A small group of 9 patients with bilateral otitis externa (included in the preceding statistics) was treated in the following manner: The ear which appeared the most severely affected received roentgen therapy alone, while the other ear received only medical therapy.

In 3 of these patients the condition was chronic, and in all 3 subjective and objective improvement was first noted in the irradiated ear. All of these were promptly rendered symptom free, but 1 had a bilateral recurrence later, which was milder and of shorter duration in the ear treated by roentgen therapy.

The aural conditions of the other 6 patients in this comparative group were acute, and all healed within one week. There was no appreciable difference in the time of healing of the irradiated and the medically

treated ears. Because in this bilateral series constitutional factors and systemic variations influencing the results in the two ears were eliminated, we attach more importance to the results than would otherwise be justifiable in consideration of the small number of cases studied. Both from this small series and from the larger series of 100 cases of otitis externa in which treatment was by roentgen therapy we have observed that chronic lesions react more favorably to roentgen therapy than to medical treatment whereas in the acute group the two methods of treatment are of approximately equal efficacy.

## COMMENT

From a rechecking of the therapeutic failures in series 1 and 2 it was found to be impossible to prognosticate from a clinical examination or from a bacteriologic study alone which conditions would resist simple medical therapy and which would recur. In general, however, those patients having a duration of symptoms greater than three months when first seen offered a much poorer chance of complete cure than those with symptoms of shorter duration. Cases of external otitis associated with seborrheic dermatitis, generalized furunculosis, diabetes and, of course, chronic purulent otitis media also offered a poor prognosis. Patients showing bilaterality of symptoms may do badly on any form of therapy largely because many of these symptoms are due to one of the previously named constitutional factors.

## CONCLUSIONS

From a comparative study of 100 cases of external otitis in which treatment was by medical therapy and a similar number in which treatment was by roentgen therapy, we find that:

1. Acute external otitis is usually a short-lived and self-limited disease. In dealing with this group roentgen therapy should be reserved for the patients with severe pain or with diffuse stenosis of the meatal canal, particularly those in whom associated purulent otitis media is suspected. A great majority of the remaining patients do well on medical therapy and do not require roentgen therapy.

2. Subacute external otitis responds about equally well to both forms of therapy.

3. Chronic dermatitis of the external aural canal is resistant to all forms of therapy. In this group, however, many conditions which were refractory to medical treatment responded to roentgen therapy, particularly those of the true eczematous type.

4. A poor prognosis is indicated by a lengthy duration of symptoms, a history of recurrences, bilaterality, or seborrheic status and the presence of purulent otitis media of a chronic type.

# SUBPERIOSTEAL TRANSCONCHAL ANTROTOMY

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The endaural operation has been chiefly used for chronic aural suppuration, and the majority of writers on the subject have refused to recommend it for acute aural suppuration. Even those who have made the greatest use of it (Thies and Thies [1]; Guns [2]; Bockstein [3]) and have not hesitated to use it in more complicated cases have refused categorically to perform it for acute mastoiditis. The grounds for this are anatomic (Rejtö [4]; Neer [5]), clinical (Staunton Wishart [6]; Babbit [7]) and surgical (von Eicken [8]; Pruvot [9]). The great difference between chronic and acute aural suppuration has been stressed by many. A résumé of these differences follows: In chronic otitis the mastoid is mostly sclerotic and the disease is more concentrated around the antrum and the tympanic cavity. The operation requires removal of the posterior wall of the aural canal and plastic use of tissue from the external auditory meatus. In acute mastoiditis there are other circumstances. The cells in many cases are widespread, the mastoid process is mostly pneumatic and inflammation may reach the remotest and deepest parts of the mastoid process. The operation requires, according to contemporary opinion (Neumann; Voss [10]), radical removal and cleansing of all the

1. Thies, C., and Thies, F.: Operative Behandlung der chronischen Mittelohreiterung durch Freilegung der erkrankten Mittelohrräume vom äussern Gehörgang aus, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **89**:137, 1912.

2. Guns, P.: La cure radicale des otorrhées chroniques par le conduit et ses résultats physiologiques, Rev. de laryng. **54**:1102 (Nov.) 1933.

3. Bockstein, F. S.: Radikaloperation durch den Gehörgang bei chronischen Otitiden, Monatschr. f. Ohrenh. **69**:776 (July) 1935.

4. Rejtö, A.: Ueber die intrameatalen radikalen Operationen, Ztschr. f. Anat. u. Entwcklngsgesch. **81**:686, 1927.

5. Neer, E. D.: Estimation of Subcortical Mastoidectomy, S. Clin. North America **10**:653 (June) 1930.

6. Wishart, D. E. S.: The Endaural Route, Arch. Otolaryng. **31**:218 (Jan.) 1940.

7. Babbitt, J. A., in discussion on Wishart.[6]

8. von Eicken, C.: Zur Freilegung der Mittelohrräume vom Gehörgang aus, Zentralbl. f. Hals-, Nasen- u. Ohrenh. **7**:681, 1925.

9. Pruvot, M.: L'évidement pétro-mastoïdien par le conduit auditif externe, Comptes rendus des séances de la Société française d'oto-rhino-laryngologie, Congrès de 1935, Paris, 1935, p. 308.

10. Voss, O., cited by Beyer, H.: Die Operationen am Ohr, in Beyer, H., and Seiffert, A.: Der Operationskurs des Hals-, Nasen- u. Ohrenarztes, Leipzig, Curt Kabitzsch, 1932, p. 152.

mastoid cells and in many cases wide drainage for the postoperative period. It is often necessary, too, with acute mastoiditis, to open and examine the wall of the sinus and the dura.

In regard to the final results of operation, likewise, there is a difference between acute and chronic aural suppuration. In operating for chronic disease the function of the ear often depends on the technic used. With the endaural method the preservation of the intratympanic structure may favorably influence the final results. With acute aural suppuration postoperative results are favorable irrespective of the method used. Generally a complete restoration of function is established.

In this way one deduces that the majority of the conditions that favor the use of the endaural method in operations for chronic aural suppuration are unfavorable to the use of the same method for acute aural suppuration. The suggestion of Lempert to use the endaural approach also for acute mastoiditis and even the more complicated conditions was widely criticized by many (Alexander [11]). Howarth and Bateman [12] recently used the endaural approach according to Lempert [13] in nearly 20 cases of acute mastoiditis and were quite satisfied with the results attained. They said that "neither condition caused any insuperable difficulty" and that the final results were good.

These good practical results are contradicted within limits by the preceding deductions. My experience,[14] and I have used a modified method for more than ten years, partly confirms the opinion of Howarth stated in the preceding paragraph. If the subjects are carefully selected and the indications are specifically in favor of this method, the results are better than might be expected. However, it is a mistake to use this method without paying attention to the fact that there is a large number of subjects for whom this operative approach is not suitable. In such an event the use of the endaural method can only compromise this

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11. Alexander, G.: Ist es empfehlenswert die akute Mastoiditis von äusseren Gehörgang aus zu operieren? Monatschr. f. Ohrenh. **64**:792 (July) 1930; cited by Bockstein.[3]

12. Howarth, W., and Bateman, G.: The Endaural Approach to the Mastoid, Lancet **2**:1168 (Nov. 19) 1938.

13. Lempert, J.: Einfache subkortikale Mastoidektomie, Monatschr. f. Ohrenh. **63**:1 (Jan.) 1929; Endaural, Antauricular Surgical Approach to Temporal Bone, Arch. Otolaryng. **27**:555 (May) 1938.

14. Matis, E. I.: (*a*) La cure radicale et l'antrotomie par la voie conquale. Opération sous-périostée, Comptes rendus des séances de la Société française d'oto-rhino-laryngologie, Congrès de 1935, Paris, 1935; (*b*) Die Indikationstellung und die technische Ausführung der Antrotomie durch das cavum conchae und vom äussern Gehörgang aus, Monatschr. f. Ohrenh. **70**:1230 (Oct.) 1936; (*c*) Die conchale Radikaloperation des Ohres, Ztschr. f. Hals-, Nasen- u. Ohrenh. **35**: 181, 1933.

method. Schall [15] wrote: "I believe the endaural route will become more popular with better selection of cases."

### OPERATIVE TECHNIC

The technic of the transconchal operation was described in a previous article.[16] It is now necessary to refer to the following changes that have been made in it:

1. The position of the patient must be such that the head can be turned in all directions, because it is only this that makes it possible to reach the various groups of remote cells during the operation. To this end the assistant holds the patient's head with both hands and turns it in the required direction.

2. Anesthesia has to be more widespread, especially over the back part of the mastoid process, and it is often necessary to combine local and general anesthesia.

3. The incision must be very long.

4. The soft tissue is elevated subperiosteally from the underlying bone over a wide area, as in this way the auricle and the soft tissue are made more pliant and so can be moved away from the site to be operated on, increasing operative possibilities. The mobility and elasticity of the auricle and the soft tissue are of the greatest importance for the performance of the operation. During the operation the self-retaining retractor must be replaced by special hooks, and the position of the patient's head must be altered in order to give a better approach to the deeper-lying tissue.

5. The removal of the infected cells requires the use of various technics, depending on the position of these cells. (*a*) The antrum is opened by the transconchal method without difficulty, in the direct way. The large opening of the antrum gives the key position for the removal of other cells; commencing with it, one removes all the diseased tissue consecutively from the nearest parts of the antrum toward the deeper-lying cells. The cells around the antrum can be easily removed. (*b*) The direct approach to the zygoma and to the cells near the tegmen and the superior walls of the meatus is best secured by this method (fig. 1 *C*). The cells between the sinus and the facial nerve are also reached without difficulty. (*c*) The removal of the apex of the mastoid requires a special technic: A retractor is placed on the lower point of

15. Schall, L. A., in discussion on Goodyear, H. M.: Radical Mastoidectomy: Use of the Tensor Tympani Muscle in Closing the Eustachian Tube, Arch. Otolaryng. **31**:219 (Jan.) 1940.

16. Matis, E. I.: Practical Points in the Transconchal Radical Mastoid Operation, Arch. Otolaryng., to be published.

the wound and the auricle is pulled downward. A gouge is inserted in a downward and backward direction. Several taps will break away the apex, and by the use of a pair of curved mastoid forceps and scissors it can be completely removed (fig. 1 *B*). The apex is often firmly attached to the periosteum and to the muscles, and therefore one must

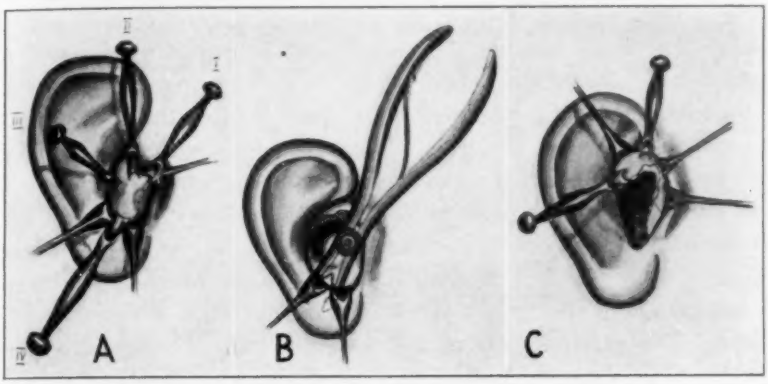


Fig. 1.—*A*, the various positions of the gouge for the removal of the mastoid cortex. *B*, the forceps in position for the removal of the apex. *C*, the position of the gouge for the removal of the zygoma and the adjacent cells.

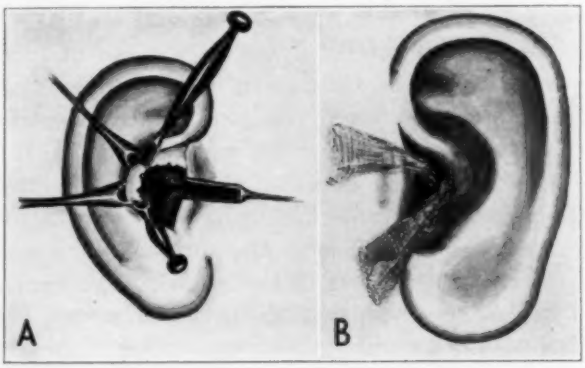


Fig. 2.—*A*, position of the gouge for the removal of the cells in the sinal-dural corner. *B*, mode of the postoperative drainage.

prepare to free it from the surrounding tissue by means of sharp curved scissors. (*d*) The removal of the cells from the sinal-dural corner is more difficult. By using sharp chisels in the direction from front to rear alternately and parallel to the tegmen and from below parallel to the direction of the sinus, one can remove wedge-shaped pieces of bone (fig. 2 *B*). Special care must be observed in this, because the end of the gouge may be directed toward the sinus and the dura mater.

(*e*) The most difficult part of the operation is the removal of the cells from behind and around the sinus, especially in cases in which there is extreme cellular development in this region. In this connection Staunton Wishart [6] said: "Difficulty may be encountered in exposing retrosinal cells and those of the tip if they are far back." In such cases it is often necessary to remove the mastoid cortex to a considerable degree. The removal of these parts demands a good technic with the chisels: The hand holding the chisel must be supported by the little finger, resting against the patient's face. The bone splinters are chipped off by a careful leverage motion of the hand holding the gouge. If the cells are much decayed, curetting is indicated for their removal. (*f*) The inner parts of the external auditory meatus are packed with gauze. The inner parts of the bony wall of the external auditory meatus must not be touched. After the cells have been removed and the wound has been cleared of bone splinters, a small incision is made on the edge between the posterior and the upper wall of the membranous external auditory meatus. The external part of the posterior wall of the meatus is like a flap which bends backward and is retained in position by gauze plugging. The flap is not thinned, and its soft tissue is left intact. The operative cavity is filled with a long narrow strip of gauze, the end of which is left hanging out of the wound (fig. 2*B*). The first dressing must be changed early, after two or three days, and subsequent changes must be made frequently, every day or at least on alternate days. The long strip of gauze must not be packed tightly into the cavity. Postoperative treatment must be undertaken more carefully than after the transmastoid operation. If during postoperative treatment the discharge increases, it is often necessary to wash out the wound. If the skin is irritated, an ointment is useful to protect it. The discharge usually diminishes after about two weeks, and the growth of granulations begins. I have seldom resorted to cauterization of the granulations, as my endeavor is to bring about filling of the wound. This generally occurs in the third week. However, drainage from the antrum has remained good until healing was complete. Complete healing of the wound comes about after various periods. It usually takes about a month, but there have been cases in which it took only three weeks, and in isolated cases a long time was required.

### DIFFICULTIES IN OPERATING

The difficulties that may be met can be divided into the five following groups:

1. Great pneumatization and development of the mastoid cells. Such conditions generally make the use of the transconchal operation inconvenient. There is a difference between the mature stage of mastoiditis,

with a clearly defined collection of pus, granulation formations and empyema, and the initial stage of the disease. It is easier to operate if the disease is in the former stage.

2. A small deep antrum, which is difficult to locate. It is easier to open such an antrum by the transconchal method, because the external auditory meatus is a sure guide to it and gives the best approach.

3. Protrusion of the sinus and a deep-lying position of the dura. The position of the sinus can never be an obstacle to performance of the transconchal operation; on the contrary, if the sinus reaches the external auditory meatus, the endaural route gives the only alternative for opening the antrum. A deep-lying dura compels one to be careful, and at the beginning to operate more from the apex of the mastoid in the direction of the antrum.

4. An abnormally situated small tract of deep-lying cells may complicate the performance of the transconchal operation. In such a case it is better to take the postaural route.

5. The greatest difficulty of the transconchal operation occurs in the case in which there are diseased cells under a layer of hard and quite healthy bone. Here it is better to continue the operation with a postaural incision.

Hemorrhage greatly interferes with the performance of the operation. If hemorrhage comes from the soft tissue, it can be stopped, but if it comes from the bone and cannot be stopped, it is better to continue by the postaural route.

Generally speaking, in isolated cases the technical difficulties of the transconchal operation for acute mastoiditis may be by no means easy to overcome. If this is found to be the case, it is better not to persist with the endaural route but to complete the operation with a postaural incision.

## FACTORS IN THE SELECTION OF PATIENTS

Subjects for the transconchal operation must be carefully selected. The selection should be based on the following points: (1) the particular condition of the patient, (2) the clinical aspect of the case and (3) the anatomic condition of the mastoid process. Taking each of these three points in turn, one may say: 1. The particular condition of the patient gives the most important indications. The aim of the transconchal operation is to diminish operative procedure and to establish transmeatal drainage. All this is needed for (*a*) old and weak patients, (*b*) those in a bad general state of health, (*c*) patients suffering from progressive tuberculosis and (*d*) those suffering from serious diabetes. 2. From the clinical point of view it is easier to operate according to the transconchal method in cases in which, first, the process has long

existed, second, the discharge is not profuse, third, there is not a high temperature, fourth, the presence of latent mastoiditis is suspected, and, fifth, there is subacute epitympanal suppuration. Contraindications are, first, the presence of subperiosteal abscess, second, the presence of complications and, third, an acute condition with profuse discharge and high temperature. 3. Roentgenograms give an approximate idea of the anatomic configuration of the mastoid process. Sclerotic and diploic mastoid processes are easier to operate on than are those of the pneumatic type with wide cellular development. Often all these indications coincide, for example, in the cases of old men, in whom gradually progressive latent mastoiditis sometimes occurs and in whom the structure of the mastoid is of a more sclerotic type with limited cellular development.

### EXPERIENCE WITH THE OPERATION

My experience in cases in which the transconchal operation for acute mastoiditis was performed shows the results to be good. In only 2 cases did I meet with any postoperative complications; in these there was abscess formation in the soft tissue of the lower parts of the mastoid process. It is assumed that the gauze was packed too tightly and left too long in the cavity. The functional results were good in every case. In many cases the operation was performed with the patient under local anesthesia and was borne well and easily. In general, healing of the wound was quicker than with the transmastoid operation, and the patient became able to leave the hospital and fit to resume his ordinary occupation more quickly. On an average, healing took about a month; this agrees with the results obtained by Howarth [12] in his cases. However, an important fact must be stressed: Suitable subjects were selected for this operation in so far as it was possible, and therefore no general conclusions on the basis of 40 cases can be drawn. From the experience I gained, I am convinced that only when the use of the transconchal method is strictly indicated and the case has been carefully analyzed is it possible to derive any real benefit from this procedure.

### COMMENT

The most important ends gained by the endaural operation in cases of acute aural suppuration are: (1) the acceleration of wound healing; (2) the making of the operative intervention more bearable for the patient; (3) the establishment of drainage through the external auditory meatus; (4) the avoidance of postoperative retroauricular fistula building, and (5) the avoidance of the formation of a postauricular scar.

In dealing with each of these five points in turn it may be said: 1. It is presumed that the more delicate endaural approach creates better conditions for quick healing of the wound. Lempert [13] and his followers [1]

suggested that subcortical mastoidectomy is the most important factor of the procedure, and Lempert always endeavored to preserve a cortical layer. I do not agree with this point of view, and I consider it unnecessary to conserve a cortical layer. On the contrary, the operation must be "subperiosteal." The importance of the periosteum for the building of bone is great, and Mosher [17] said: "It is common belief that bone regeneration comes chiefly from the periosteum." If the periosteum is responsible for the regeneration of bone, it is not clear what advantage is gained by preserving a cortical layer. With the transconchal operation the vitality of the external periosteum is preserved, because this procedure leaves all the soft tissue, with the blood vessels intact, attached to the external periosteum, an essential for the good regeneration of the bone; thus, the transconchal operation gives better conditions for the healing of the wound than does that performed with the postaural approach, in which the skin and periosteum are turned back to expose the mastoid process. After the operation there is a partial tendency of the periosteum and the subcutaneous tissue to shrink (Kazanjian and Converse [18]), resulting in delay of wound healing. I [14c] have expressed the belief that the preservation of the periosteum is the most important advantage of the method herein described. 2. With the transconchal method it is easier to operate with the patient under local anesthesia, and he bears the operation better, but this advantage in cases of acute mastoiditis is not so important as in cases of chronic aural disease. 3. Many writers on this subject prefer to establish postoperative drainage through the external auditory meatus (Blumenthal; Claus; Torrini [19]; Atorre [20]) in cases of acute mastoiditis too. The advantages of this method of postoperative drainage in dealing with acute mastoiditis are not yet clear. 4. In my own practice I have rarely seen the building of a postauricular fistula after simple mastoidectomy, and I think that the problem is not real, for by taking precautions it can be avoided in most cases. 5. I consider that the formation of a postauricular scar is usually of little importance.

The use of curets and bone scoops is important in the performance of the transconchal operation. A special technic can be applied to remove the deeper-lying cells without wounding the sinus, the dura or the facial nerve. I proceed in the following manner: After opening the antrum, I remove the deeper-lying cells, like the periantral. This permits one to

17. Mosher, H. P., in discussion on Kazanjian and Converse.[18]

18. Kazanjian, V. H., and Converse, I. M.: Reconstruction After Radical Operation for Osteomyelitis of the Frontal Bone, Arch. Otolaryng. **31**:94 (Jan.) 1940.

19. Torrini, cited by Atorre.[20]

20. Atorre, G.: Les premiers 100 cas des mastoïdites aiguës opérées par la méthode de Torrini, abstracted, Rev. de laryng. **56**:888 (July) 1935.

follow the various cell tracts, beginning in the region of the antrum, by boring and scooping, using both hands. In this way a wide area of the most important and most affected parts is quickly cleansed. After this it is easier to remove other, more superficial, cells. By using scoops and working from the inner parts in the direction toward the outside, one can easily and safely remove these cells. The transconchal method is generally favorable for the use of scoops but not in those cases in which the bone is very hard.

## SUMMARY AND CONCLUSION

Anatomic conditions are not favorable for the use of the endaural operation in cases of acute mastoiditis. Practical results are good provided there is strict selection of suitable subjects.

The position of the patient's head during the operation must be such that it can be turned. Local anesthesia is necessary in every case in order to avoid hemorrhage. A long incision must be made and the soft tissue widely elevated. The antrum must be opened at the beginning. Commencing with it one removes all the affected cells of the antrum, then those which surround the antrum. The cortical layer is widely removed. A special technic is used for the removal of various groups of cells, such as those of the zygoma and the apex.

The indications for the use of the endaural operation must be found in the particular condition of the patient and in the particular clinical development.

Disregarding the theories of the subcortical procedure, I suggest that the principle of the subperiosteal method conforms more with knowledge of the regeneration of bone. On this is based the technic described in this paper.

# BRONCHIAL ASTHMA IN RELATION TO FOCI OF INFECTION OF THE UPPER RESPIRATORY TRACT

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As an item of historic interest, it is stated that Aretaeus described the asthmatic attack as early as the second century. Even today such attacks are one of the important clinical expressions of human hypersensitiveness and are responsible for thirteen million days of illness per year among some half million victims of asthma in the United States.

Asthma was described by Osler as a

> reaction of an anaphylactic nature in sensitized persons, in others possibly a reflex neurosis, characterized by swelling of the nasal or respiratory mucous membrane, increased secretion, spasm of the bronchial muscles, with dyspnea chiefly respiratory.

He stated that there is no essential difference between hay fever and asthma; in the one the nasal portion of the respiratory tract is affected, in the other the bronchial and in many instances both. As used in this paper, the term "asthma" refers to true bronchial asthma in its relation to infection of the ear, nose and throat. Serum disease and other Arthus phenomena from antitoxins may be spasmodic asthma or the forerunner of bronchial asthma; but for the present "all that wheezes is not asthma."

A questionnaire was sent to three hundred physicians in the United States, with the purpose of obtaining for comparison opinions of a representative group from every section. Naturally the list included a preponderance of ear, nose and throat specialists, since it is from the viewpoint of the otolaryngologist that the paper is written. A few roentgenologists, general practitioners, internists, psychiatrists and pathologists and a number of allergists were included in the group.

Seventy-five per cent of the questionnaires were returned. The original questionnaire with the added average of results follows.

1. In your opinion what per cent of asthmatic patients are cured permanently? Seventy per cent estimated none to 5 per cent.
2. Do you think asthmatic patients can be relieved by surgical procedure or by treatment for:
   a. Sinusitis? Yes, 91 per cent.

Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society, Inc., June 1940.

b. Infected adenoids and tonsils? Yes, 70 per cent.
c. Infected teeth? Yes, 40 per cent.
d. Mastoiditis? Yes, 35 per cent.

3. Do you think there is always a focus of infection in the ear, nose of throat of an asthmatic patient?
Yes, 11 per cent. No, 89 per cent.

4. Do you think asthma in adults may be prevented by the removal of foci of infection from children as soon as asthma is noticed?
Yes, 40 per cent. No, 60 per cent.

5. Do you think an allergic reaction can result from bacterial protein? Yes, 98 per cent.

6. Do you think asthma is the end result of a previous allergic condition? Yes, 76 per cent.

7. What factors do you think influence asthma? Please check:
a. Allergies 100 per cent.
b. Infection 92 per cent.
c. Season 82 per cent.
d. Fatigue 82 per cent.
e. Emotional instability 75 per cent.
f. Hormones 67 per cent.
g. Others: Sixteen different factors were listed.

8. Do you think polypi of the nose, throat and ear in an asthmatic patient are due to allergy, or do they result from an infection?
Allergy, 81 per cent. Infection, 79 per cent.

9. Have you seen any asthmatic patients with polypoid sinusitis, whose roentgenograms showed no abnormality of the sinuses?
Yes, 55 per cent. No, 45 per cent.

The appearance of the nasal mucosa of an asthmatic sufferer is rather typical, the general color being a bluish gray. The disease chiefly involves the turbinates, which become boggy and often have a pitted appearance; but probably all areas are involved that are supplied by the parasympathetic nervous system. During an acute attack the mucosa is streaming with secretions. The exudate from the trachea and bronchi is thicker and more viscid. Rarely is the discharge as thin as that from hay fever.

If there is any question whether the patient is asthmatic or not, a careful examination of the nasal secretion for eosinophils will be of great aid. Some pathologists claim that the presence of these cells in significant number is absolute evidence of the presence of an allergic process. Dr. A. A. Eggston, of New York, and other hematologists report that often during an acute attack of hay fever there are no eosinophils, but there is always eosinophilia in asthma. And there may be a high eosinophil count in the secretions of a patient with chronic sinusitis with no clinical manifestations of allergy whatever.

Ninety-one per cent of the physicians answering the questionnaire stated that sinusitis is the chief focus and that the asthmatic patient may be benefited by treating the sinusitis. If the patient does have sinusitis (and I think all persons with asthma do), then he is harboring germs of some type in one or more sinuses. They may be bacilli, cocci, yeasts, molds, filtrable viruses or a combination of such germs. The first cold a child has represents the first invasion of the posterior ethmoid cells by these germs.

It was interesting to note the emphasis placed on the antrums as foci of infections, in preference to other sinuses. Next most emphasized were the ethmoid cells, with little attention given the sphenoid and frontal sinuses. Yet, in examining adults, I think, one often overlooks a hidden focus in the sphenoid sinus. An infection in a sinus is not necessarily attended with visible pus, because many streptococci and filtrable viruses do not produce pus, and these may be the worst offenders.

The literature of sinal disease and asthma is voluminous and controversial. For further discussion on this point the reader is referred to the articles cited in the footnotes.

The question of polypi brought out a diversity of opinion. Those who attributed the formation of polypi to allergy seem to have a slight lead, with 81 per cent, while 79 per cent favored infection as the cause of polypi of the ear, nose and throat. Many did not comment on this question. A few divided polypi into three classes: those due to allergy, to infection, and to a combination of the two. Some specified that polypi of the ear are all due to infection and those in the nose and throat to allergy. According to Rackemann,[1] there is an "*x*" factor, histamine, causing polypi.

In the clinic of the Manhattan Eye, Ear, and Throat Hospital, in New York, where literally thousands of patients are seen, those with polypi of the ear all gave a history of an infection of the middle ear or mastoiditis; but only about 1 per cent had an allergic condition.

Numerous polypi of the nose have been observed, varying in size and extent from a polypoid membrane to multiple polypi which packed all the sinuses and hung down the back of the oropharynx. Many of the patients had asthma; all had some sinal infection.

I have seen polypi apparently shrink away under treatment for allergy, only to appear again when the treatment was relaxed, and have seen them become waterlogged and juicy as the asthma became acutely active. Some seem to subside spontaneously when the disease

1. Rackemann, F. M.: (*a*) Clinical Allergy, New York, The Macmillan Company, 1931; (*b*) Allergic Diseases, New England J. Med. **221**:234 (Aug. 10) 1939.

is in a quiescent state. In replies to the questionnaire, a few physicians reported complete disappearance of polypi of the nose during treatment for allergy.

One group of pathologists think there are two separate kinds of polypi. Others claim that there is no difference between a polypus due to infection and one due to allergy. Nor do they consider polypi of the ear any different from those of the nose or the sinuses. All who commented in the questionnaire on polypi of the ear expressed the opinion that they are due to infection.

In many instances I have seen the condition of an asthmatic patient with polypoid sinusitis markedly improved by a judicious operation. I have also seen some patients whose trouble became worse afterward. The majority of those with chronic sinusitis and polypus formation seen at the Manhattan Eye, Ear, and Throat Hospital do not have asthma or any other apparent allergic manifestation, unless one considers polypi as evidence, and there are many asthmatic patients who do not have polypi. The majority of asthmatic persons referred to the ear, nose and throat specialists have polypi, and all have some pathologic condition of the nose or they would not be sent to otolaryngologists. It is generally conceded that a surgical procedure should not be performed on the sinuses of an allergic patient until after allergic treatment has been instituted.

A roentgenogram usually is of value in determining whether the sinuses contain polypi or not; but if the lining membrane is edematous, as it is during an attack, it may be difficult to interpret the film correctly. Fifty-five per cent of those answering the questionnaire said they had encountered a case of polypoid sinusitis and asthma in which a negative roentgenogram was obtained. I have studied at least 3 cases of asthma in which the ethmoid sinuses and the antrums were packed full of polypi while the roentgenograms showed these sinuses clear. On the other hand, in cases of chronic polypoid sinusitis without asthma similar negative roentgenograms have been seen. For example, several of the physicians answering the questionnaire reported that they had encountered many cases of polypoid sinusitis in which the condition failed to register on the average roentgenogram.

If the mucous lining is to be studied, therefore, a light film should be made. It is often necessary to fill the sinal cavity with some opaque substance (iodized poppyseed oil) before a true estimate of the thickness of the mucosa can be obtained. For the sinus with the thick bony wall, stereoscopic films will bring to light polypoid degeneration that cannot be seen in the single flat film.

Thirty-five per cent of the physician who answered the questionnaire expressed the belief that by treating a chronically discharging ear (mas-

toiditis) asthma may be relieved. In illustration of this point the following case history may be cited:

A white woman aged 30 had measles at the age of 7, which was followed by a discharge from the right ear and pneumonia. Until this sickness she had never had allergic symptoms, but after these infections sinusitis and bronchial asthma developed. Later an adenoidectomy and a tonsillectomy were done, followed by a submucous resection of the nose. Her ear continued to discharge; her asthma and sinusitis persisted, but there were never any polypi of the nose or ear. In 1936 a radical mastoidectomy was performed on the right side for reasons other than the asthma but with the hope that it might help the asthma by ridding the organism of a focus of infection. (I think a chronically discharging ear is just as much a focus of infection as a chronically discharging nasal sinus, being, in fact, a sinus of the mastoid area.) Not only did the removal of this focus alleviate the general rheumatic condition and headaches, but by closing off the draining eustachian tube it stopped inflammation of the right side of the throat. Four years have passed and except for two mild attacks during menstruation the patient's asthma has been 90 per cent cured. She still has a low grade infection in the ethmoid sinuses and the antrums, but it seems that the right mastoid was the chief focus of infection in this case.

Forty per cent of the physicians answering the questionnaire stated the belief that infected teeth can be a source of infection influencing asthma. I personally would eradicate a focus of infection anywhere but there have been few cases in which I thought this source a prominent factor. Dr. Luther B. MacKenzie, of New York, reported a spectacular cure of asthma from infection of the teeth. If there is a communication into the antrum, then no doubt an infected tooth is a factor.

Sixty per cent of the physicians answering the questionnaire checked infection of the tonsils as an influential factor, and 80 per cent, infection of the adenoids. Many expressed the belief that performance of adenoidectomy and tonsillectomy in children is an excellent procedure for the prevention of asthma and sinusitis in later life.

Whether there is always a focus of infection in the ear, nose or throat of the asthmatic patient is a difficult question to answer because of the word "always." Eleven per cent of the physicians answered this question in the affirmative. None of the 11 per cent was an allergist, and all of the 11 per cent were from cities. While 89 per cent said "no," a great number of these qualified their statement with "usually" or "not always." Some eliminated aural infection completely, but said that the nose is a frequent and the throat an infrequent focus influencing asthma. It is noticeable, however, in talking with the physicians that many are inclined to think there is infection, but they hesitate to put the opinion in writing.

Forty per cent of those who answered the questionnaire expressed the belief that asthma may be prevented in later life by removing foci

of infection from children as soon as the asthma is noticed; this means chiefly adenoidectomy and tonsillectomy with treatment of a condition affecting the ethmoid sinuses. The underlying philosophy is: Give the child a chance, because every day he is kept well he is in a way being vaccinated against all diseases in later life. Especially in relation to asthma is prevention worth more than cure. Too many low grade infections of the posterior ethmoid sinuses of children are allowed to pass unnoticed.

The first attack of running nose a child has is his first sinus infection, and the sooner drainage and aeration are given to the ethmoid sinuses, the better he will be. If the child is under 5 years of age, remove the adenoids, at least. They are pathologic, anyway, and I can conceive of no good they do. If he is over 5 and the tonsils are infected, remove them also. Their function has probably ceased by this time or probably will cease at puberty.

If there is blockage of the nose due to a deviation of the septum, I see no reason to wait until the patient is an adult to do a submucous resection. A partial submucous resection, done with care, will give better aeration through the nose, and an adenoidectomy will give better drainage for the ethmoid sinuses down the posterior nasopharynx. I have frequently done this combination on children, with decided improvement of the patients.

I have at this writing 7 cases of children who formerly had typical attacks of asthma but have not had an attack since their adenoids and tonsils were removed four years ago, to alleviate running of the nose with asthma. On the other hand, I have heard of children who had attacks of asthma after operation on adenoids and tonsils. Such patients may have had sufficient infection of the ethmoid sinuses to outbalance the good done by removing the adenoids.

Chobot,[2] of New York, said of a series of asthmatic children studied by him and his associates that in the majority of them the first attack of asthma followed an acute infection of the respiratory tract. Such an infection is without doubt the most important single factor in the production of an attack. Other investigators have found a demonstrable change in the peribronchial tissue of the lungs in all cases of acute infection of the upper respiratory tract.

Whether or not the belief is held that allergic symptoms are due to infection, experience does not justify the removal of adenoids and tonsils for the relief of allergic symptoms referable to other factors. One must differentiate between pure allergy, pure infection and a combination of the two. I do not believe that operation on adenoids and tonsils will help hay fever or allergy per se but it will do no harm to

2. Chobot, R.: Asthma in Children, Am. J. Dis. Child. **45**:25 (Jan.) 1933.

remove suspicious tonsils after the patient is 5 or 6 years of age. Other acute respiratory infections precipitating an asthmatic attack are pneumonia, whooping cough, measles, scarlet fever and diphtheria.

It was an almost unanimous opinion of the physicians answering the questionnaire that an allergic reaction can be a response to a bacterial protein. There were only four who definitely said "no," and a few qualified their statements by saying "rarely." If one grants that this is possible, then it is also possible for asthma to result from a focus of infection. Rackemann [1a] stated that bacterial asthma is characteristic of the late anaphylactic phase of incomplete immunity and spoke of it as the endogenous or intrinsic source.

A great many persons with asthma give a history of some previous allergic condition, and 76 per cent of answers to the questionnaire indicate that asthma is the end result of an allergic reaction. Yet there are many asthmatic patients who in their case histories tell of no other allergic symptoms. I recall one article in which the author stated that in more than two thirds of untreated patients with hay fever sooner or later some asthma develops. The question is why do some allergic conditions manifest themselves as asthma and others as hay fever, urticaria, gastrointestinal upsets, headache and failing of vision?

It seems that allergy has lately become so common an explanation that everybody is allergic to something. It may be that all persons are allergic to everything when they are born (if you wish to put it that way) and must gradually become sensitized, more or less, to these foreign substances. Possibly that is the way bacterial toxins act—through the mechanism of allergy. Rowe,[2a] Rackemann [1] and others have defined allergy as an altered reactivity to foreign substances, as compared with the normal.

Since 100 per cent of the physicians agreed that allergy is the prime factor in asthma and 92 per cent agreed on infection as an influential factor, one may compare the whole process to a shell load: The explosive charge is allergy; the propelling charge, infection, and the ignition charge, all excitants, such as pollen, climate and gases. Any one of these primers may set fire to the powder, causing the explosion called asthma.

That strong emotion may precipitate or cause an attack is held not only by psychiatrists but by 75 per cent of the physicians who answered the questionnaire. A review of the literature on this subject shows that contributions have come mostly from the Germans. Moss submitted that a psychopathologic condition is usually the primary and most important factor in asthma and that psychotherapy deserves first place in its treatment. McDermott and Cobb, of the Massachusetts General

2a. Rowe, A. H.: Clinical Allergy, Philadelphia, Lea & Febiger, 1937.

Hospital, found that in 37 out of 50 cases asthma seemed to have an emotional component. Females predominated 2 to 1 in the emotional group, while males predominated in the same ratio in the nonemotional group.

As for hormones, 67 per cent of the physicians who answered the questionnaire expressed the opinion that endocrine principles constitute an influencing factor. Garretson [3] said it is axiomatic that the person who has the normal amount of epinephrine in the circulating blood never has any symptoms of allergy.

This brings up the big subject of the involuntary, or autonomic, nervous system of the nose and its action on smooth muscle and glandular secretion. The essentially neurotic character of asthma is shown by the occurrence of paroxysms due to spasm of the circular muscles of the bronchial wall. These muscles are supplied with parasympathetic fibers of the vagus nerve. Both the sympathetic and the parasympathetic system supply the glands of the nose and the lacrimal glands, but the parasympathetic is by far the more important system, according to Hubert.[4] From the medulla, the large superficial petrosal nerve supplies the sphenopalatine ganglion, that area in the nose being called the "trigger zone." It is a vicious cycle any way one figures it. All otorhinolaryngologists have observed cases in which asthma resisted every form of treatment, only to be relieved by a sudden fright in an automobile accident or some similar shock, which, according to Cannon, of Harvard, lowers the threshold of epinephrine secretion.

Reports from the ragweed sections of the country do not place any more emphasis on season as an exciting factor than do reports from other sections. But in all sections where there are patients with hay fever, pollens are given as an exciting cause of their asthma. Eighty-two per cent of the physicians who answered the questionnaire stated that season is influential.

Fatigue may bring on an attack of asthma in some cases and was voted a factor by 82 per cent, while in other cases violent exercise is recommended for overcoming an attack.

Infection is a causative agent of asthma in the opinion of 92 per cent of the physicians, this opinion being more strongly held by those of the western and southern than by those of the eastern section. I believe that if the physician takes a careful history of the patient from infancy he will find that there has been an infection of the upper respiratory tract before the asthmatic attack in all cases.

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3. Garretson, W. V. P.: Allergy: A Neuroendocrine Interpretation, M. Rec. **141**:269 (March 20) 1935.

4. Hubert, L.: The Involuntary Nervous System of the Nose, and the Mechanism of Some Obscure Nasal Symptoms, Laryngoscope **32**:493 (July) 1922.

Other factors that influence asthma, aside from allergy (reported by 100 per cent of the physicians who replied to the questionnaire), infection (reported by 92 per cent), season (reported by 82 per cent), fatigue (reported by 82 per cent), emotional instability (reported by 70 per cent and hormones (reported by 67 per cent), are changes in temperature or climate, exposure to irritating gases, humidity and fog, chronic acidosis, altered chemical conditions of the body, vasomotor instability, sympathetic and parasympathetic imbalance, water imbalance (salt), pregnancy, age, habit, neurosis, fits of laughter, obstruction to breathing and heredity. Such a diversity of opinion demonstrates how far physicians are from certainty of the real cause.

I am sure all otorhinolaryngologists have encountered cases in which most of the factors enumerated seem to play a part; but the literature is replete with writings naming as allergens everything from wine, women and song to the west wind. Physicians will have to separate true bronchial asthma from general allergy before they can get a clear conception of the etiology.

The average percentage of asthmatic patients estimated to be cured is from none to 5, which is the opinion expressed by 70 per cent of those responding to the questionnaire. Twenty-six per cent considered that 5 to 40 per cent of asthmatic patients are cured, while 4 physicians (2 from Georgia, 1 from Texas and 1 from Nebraska) estimated that as many as 50 per cent are cured. In regions where ragweed grows and the hay fever victims are many, as Illinois, Indiana and Ohio, the percentage of persons with asthma estimated to be cured is the same as in Washington, Oregon, Colorado, Nevada, Idaho and New Mexico, where there is no ragweed. Interesting also is the fact that the estimate of physicians of large cities as to number of asthmatic patients cured is lower than the estimate of physicians in smaller towns and in the country. In the big cities, New York, Chicago and Philadelphia, all the physicians estimated under 5 per cent cured, the unanimous opinion being that cured patients are children and young adults. In cases in which there was a pathologic condition of the lungs together with definite infection of the sinuses, none was reported cured.

Treatment consists, first, of prophylaxis for children, i. e., removal of adenoids, tonsils and nasal obstruction and careful and conservative treatment of the ethmoid sinuses, antrums and other foci of infection as soon as the first attack is noticed. Other measures consist of the administration of standard palliative drug, vitamins and vaccines, with care of underlying factors as outlined in the numerous textbooks and current articles. Personally, I do not think asthma will be cured permanently, especially in adults, until the underlying pathologic conditions of the nose are cleared up.

# USE OF LAMINAGRAMS IN LARYNGOLOGY

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In view of what is to follow there is a well known fact to be called to mind, and that is that in a roentgenogram all structures capable of absorbing the roentgen beam cast their shadows. The intensity or depth of these shadows is dependent on the density of the structures traversed and their distance from the film. Thus, a composite image of all the structures lying in the path of the roentgen beam is produced. These interfering images greatly limit the usefulness of roentgenograms. It has been found that the interference can be overcome to a remarkable degree by imparting a coordinated, synchronized movement of x-ray tube and film about a fixed point during the exposure. All objects in the plane about which movement takes place are, so to speak, "in focus," and those outside the plane are "out of focus" and are blurred because the shadows are displaced. The degree of displacement, or blurring, because of lack of focus, depends on the distance of the object from the plane of rotation and on the amplitude and character of the movement.

For the past few years this principle has been applied in roentgenography by many investigators. There are five principal types of apparatus for carrying out the selective roentgenographic procedure. These are, in order of their appearance in the literature, the stratigraph of Vallebona,[1] the tomograph of Grossmann [2] and Chaoul, the planigraph of Ziedses des Plantes,[3] the laminagraph of Kieffer and Moore [4] and the

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Read at the Sixty-Second Annual Meeting of the American Laryngological Association, Rye, N. Y., May 27, 1940.

From the Department of Otolaryngology and the Edward Mallinckrodt Institute of Radiology of the Washington University School of Medicine.

1. Vallebona, A.: Una modalità de tecnica per la dissociazione radiografica delle ombre applicata allo studio del cranio, Radiol. med. **17**:1090-1097, 1930; abstracted, Radiology **17**:647, 1931.

2. Grossmann, G.: Tomographie, Fortschr. a. d. Geb. d. Röntgenstrahlen **51**:61-80 and 191-209, 1935.

3. Ziedses des Plantes, B. G.: A New Method of Differentiation in Roentgenography (Planigraphy), Acta radiol. **13**:182-191, 1932.

4. Moore, S.: Body Section Radiography, Radiology **33**:605-614, 1939.

biotome of Bocage,[5] who was the discoverer of the principle. There are many simple modifications of the more elaborate types of apparatus for making selective roentgenographic examinations. There has been a considerable degree of confusion of the terms applied to this method of roentgen investigation. The work of a particular type of apparatus has been described by a term which should be restricted to that of a radically different apparatus. "Stratigraphy" should be used only to designate the technic employed with Vallebona's apparatus, "tomography," to designate that employed with the Grossmann and Chaoul tomograph. "Planigraphy" is extensively employed generically, but the term has the drawback that it also refers to a process in printing and to one in the reduction of drawings. "Laminagraphy" is a term which was coined to apply to the selective roentgenographic procedure which is carried out with the particular apparatus known as the laminagraph. The recommendation is made that "body section roentgenography" be the general term to cover all these procedures. *Radiotomie,* suggested by Bocage, if anglicized to "roentgenotomy" and popularized would be a more desirable term.

It is out of place here to go into the details of the chronology of the development of body section roentgenography and the descriptions of the several types of apparatus designed for this purpose.

In general, all methods disperse shadows of structures overlying and underlying the plane or layer which it is desired to photograph. This dispersion, as has been said, is a function of the character and amplitude of movement of tube and film. The more compound the movement is, the more symmetric the dispersion of undesired images. Conversely, the simpler the movement, the less the dispersion. So far, in our hands, the most desirable movement is that on a parabolic curve. Description of the mechanical details by which this is accomplished will be omitted.

In all methods of body section roentgenography it is possible to adjust the point about which movement takes place in such a fashion that one can obtain a roentgenogram of a predetermined, selected layer of the body. Since the dispersion of unwanted shadows is the first consideration, it follows that the greater the superimposition of normal anatomic structures, the greater the dispersion and the clearer the resultant roentgenogram. The selective method is of decreasing value when the superimposition of normal anatomic structures is diminished. The second important point is that the thickness of the layer investigated can be as little as 2 to 5 mm. of clear visualization or clear "focus." Obviously the thinner the layer, the greater becomes the value of minimal density contrasts. These two points determine the fundamental value of body section roentgenography in the examination of normal anatomic

5. Bocage, A. E. M.: French patent no. 536464; Présentation d'appareil; le biotome, Bull. et mém. Soc. d'électro-radiol. méd. de France **26**:210-216, 1938.

structures. When pathologic states produce an abnormal increase of density or the converse or induce unwanted shadows, body section roentgenography is of the utmost value.

The laminagraph can approximate all the movements so far evolved for the x-ray tube and film, and it has demonstrated superiority in the symmetry of its dispersion of unwanted shadows, or blurring, with the spiral movement of tube and film. Like the tomograph and its simpler modifications, the laminagraph is usable only with the patient in the recumbent position, whereas the commercial planigraph, the biotome and the stratigraph are used with the patient in the erect position.

As pointed out previously, body section roentgenography has its greatest value in the examination of those anatomic regions which are most obscured by interfering shadows in the standard roentgenogram. Reference has been made to the minimum contrast in density. It follows, then, that this method has its chief value in the examination of all parts of the respiratory tract and in the examination of the skeleton, because in each instance both great superimposition of structures and natural contrast of density are in play. In the examination of the abdominal viscera or other soft structures the method is of limited value, even when used in conjunction with contrast mediums.

Investigators are generally agreed on the value of body section roentgenography for the examination of the pulmonary area, in view of the fact that the ordinary roentgenogram is much obscured by the interfering shadows of the bones of the thoracic wall and that pathologic processes so readily either increase or decrease the normal contrast between the air content of the lungs and the surrounding structures. For the study of lungs involved in acute disease in which alterations of density are wanting, this method is not of value—for example, the lungs of patients with acute pulmonary tuberculosis before cavity formation or fibrosis has taken place. Body section roentgenography can reveal consolidations in the lung of either an infectious or a neoplastic nature when they are undiscoverable by any other means of examination. Cavitation is found when its presence is unsuspected and when the cavity is invisible on the conventional roentgenograms. Areas of consolidation can so mask excavation that frequently cavities have been found only by study of laminagrams. Furthermore, their precise location is known, and the third dimension can be established with, for all practical purposes, complete accuracy. For this reason laminagrams are invaluable to the thoracic surgeon as a guide in his approach to cavities which are to be drained externally. They are a most helpful guide in the use of collapse therapy for tuberculous patients, particularly so in the use of thoracoplasty for tuberculous patients in whom there are signs of activity but standard roentgen examination gives no indications. There have been instances in which an unsuspected tuberculous cavity has been found in the contralateral lung of such a patient. . Cavities produced by

the breaking down of a bronchiogenic tumor have been shown, along with the antecedent bronchial occlusion (fig. 1). Bronchial fistulas connected with an empyema can be shown, and bronchial branches as small as 3 to 4 mm. in diameter have been shown altered either in position or in patency. The precise limits of an encapsulated empyema or an interlobar empyema have been determined with laminagrams. Opaque foreign bodies obscured by atelectasis, infiltration and other

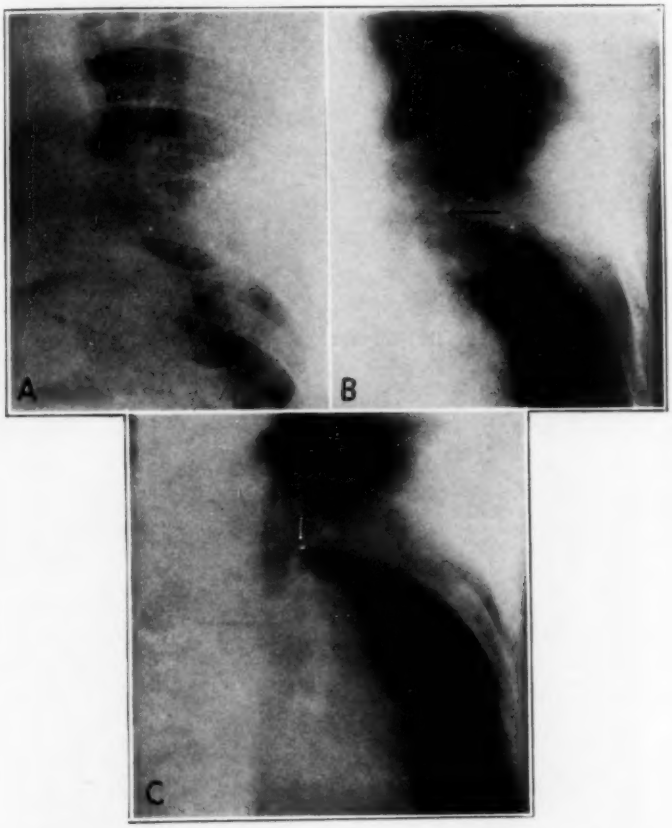


Fig. 1.—*A*, conventional roentgenogram, and *B*, laminagram, of the chest, showing area of atelectasis in the lung. The arrow indicates the termination of the bronchus to the atelectatic area. *C*, laminagram of area shown in *A*. The arrow indicates the excavation in the lung. The diagnosis of bronchiogenic carcinoma was confirmed by autopsy.

processes have been discovered where their presence was unsuspected—for example, the crown of a tooth in an abscess cavity (Wilson [6]). By

6. Wilson, H. M.: Exploration of the Thorax by Body Section Roentgenography, Radiology **33**:598-604, 1939.

varying the density of the film it should be possible to find nonopaque foreign bodies in the smaller bronchi.

With a suitable degree of density, which can be determined only by trial and error, it is possible to show the vascular pulmonary tree

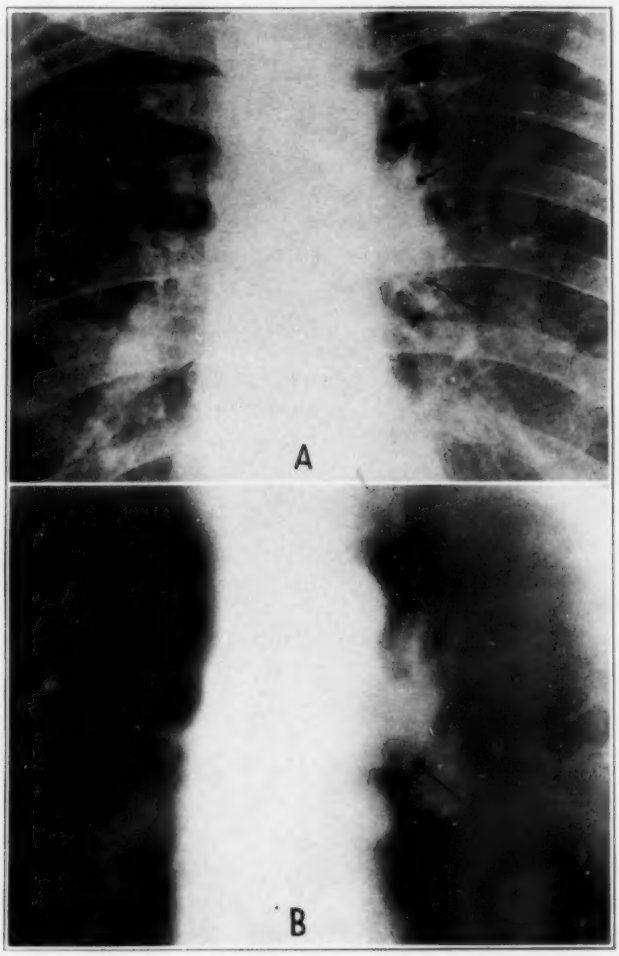


Fig. 2.—*A*, conventional roentgenogram of the chest, showing what was suspected of being a mediastinal tumor in the left hilus of the lung. *B*, a laminagram identifies the suspected tumefaction as the left pulmonary artery.

throughout a large portion of its extent. In one instance what was suspected of being a pulmonary tumor was found to be an anomalous portion of the vascular tree (fig. 2).

The trachea and the two main bronchi can be accurately shown and their location, patency and caliber consistently determined with body section roentgenography (fig. 3).

The condition of smaller bronchial branches is frequently determined when both roentgen and bronchoscopic examinations have failed to reveal the true condition. Laminagrams are not infrequently valuable in the study of bronchial branches which are not accessible to the bronchoscope and are difficult to reach with bronchographic procedure, i. e., those in the upper portions of the lungs. In the examination of the lower half of the lungs the value of body section roentgenography is more largely shared by bronchography and bronchoscopy.

Examination of the paranasal sinuses with the laminagraph is one of the newest applications of the apparatus. It has not been used in any

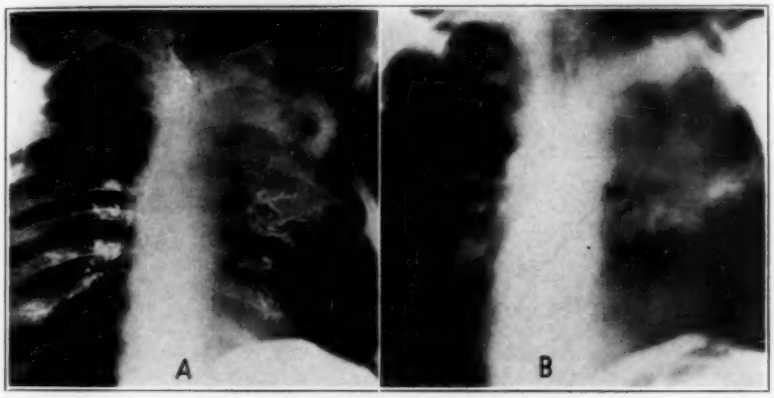


Fig. 3.—*A*, conventional bronchogram, showing incomplete filling of the bronchial branches to the upper lobe. *B*, laminagram of the same area. The arrow indicates the point of narrowing of the bronchial branches. The indications of the laminagram were confirmed by autopsy.

way commensurate with its possibilities in the examination of this portion of the respiratory tract. This is an anatomic region in which overlying bones greatly limit the scope of conventional roentgenography (fig. 4). Our clinical experience has amply confirmed this statement. The second consideration in body section roentgenography, namely, the thinness of the layer photographed, has an important bearing on the minimal contrast in density in this region. In the examination of the ethmoid cells laminagrams reveal the size and position, extensions and other anomalies and the pathologic states far more clearly than is possible with standard roentgenographic procedures, however extensively they may be carried out (fig. 5). This is also true of the examination of the sphenoid group, both in the anteroposterior and the lateral projections. The conventional roentgenograms of the maxillary sinuses

generally suffice, but there is the occasional case in which a pathologic condition is revealed by laminagrams when it was entirely unsuspected, even though contrast mediums were employed (fig. 6).

So far we have made no practical application of the laminagraph in the study of the pneumatic structure of the temporal bone. However,

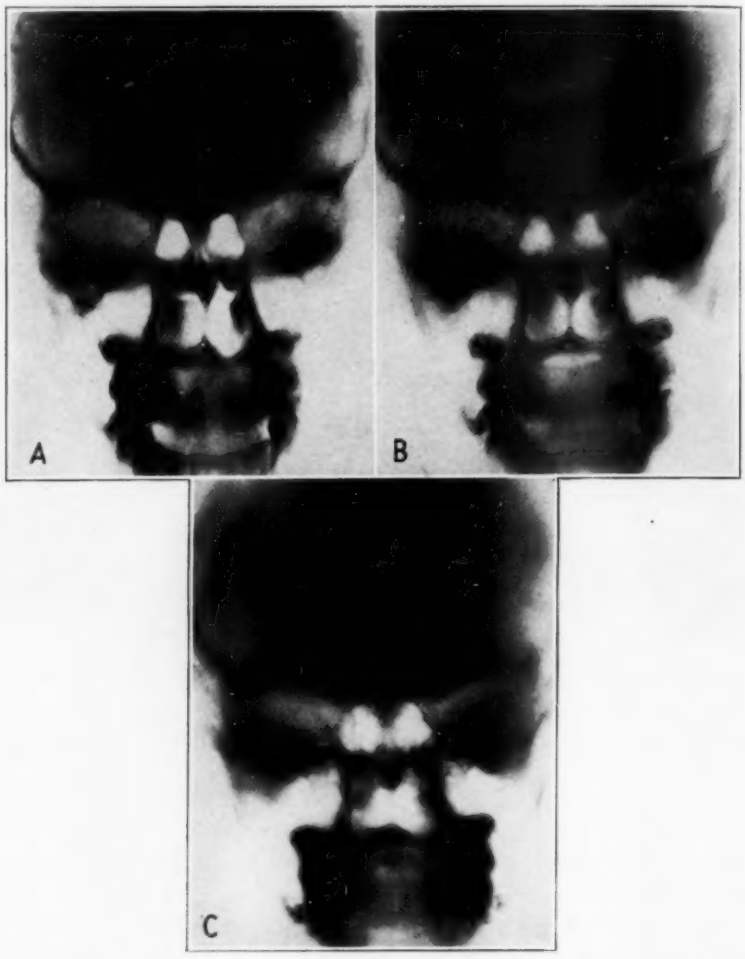


Fig. 4.—Laminagrams of the paranasal sinuses made at 5 cm. (*A*), 6 cm. (*B*) and 7 cm. (*C*) from the plane of the face. At 5 cm. the anterior ethmoid cells are clearly shown; at 6 cm., the posterior ethmoid cells, and at 7 cm., the sphenoid cells. These are optimum planes, established by sectioning through the head of a cadaver.

the auditory canals can be revealed throughout their extent in the rare cases of nondevelopment of the auricle. Body section roentgenography is the most accurate way of establishing enlargement of the internal

auditory meatus when tumor of the eighth nerve is suspected. We have had operative confirmation of laminagraphic indications in 2 cases. Any alteration of the auditory canal, either enlargement through the growth of soft tissue or decrease in size through bony growth, is discoverable with this method. The presence, the absence or the size of the groove for the lateral sinus can be shown in the case of the adult patient. It is improbable that this would be possible in the case of the younger patient because of the slight development of the groove. It is in the latter case, however, that the knowledge would be of the most value. There is no evidence to suggest that thrombosis of the lateral sinus can be visualized with laminagrams.

The condition of the articulation of the mandible with the temporal bone can be established by laminagrams when it is impossible to do so

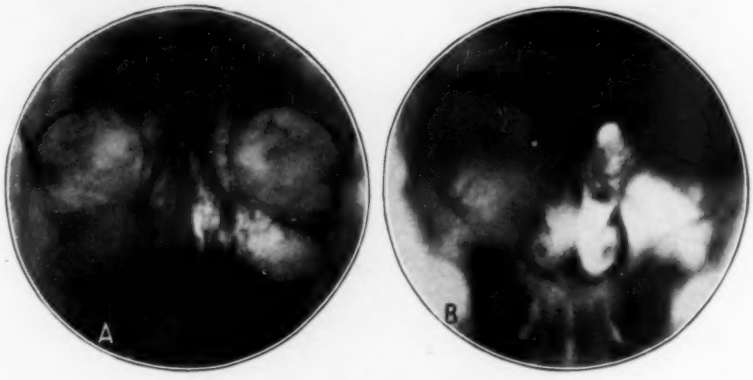


Fig. 5.—*A*, conventional roentgenogram showing empyema of the right maxillary antrum. *B*, laminagram of the area shown in *A*. Note the opacity of the ethmoid cells on the involved side. There was operative confirmation of the conditions shown by the laminagram.

with conventional roentgenograms, because this joint is heavily overlaid by the zygomatic process and other bony structures. Deformities, erosion and fractures of the condyloid and the glenoid fossa have many times been revealed, and the laminagraph has proved to be of great value in the diagnosis and treatment of the "temporomandibular syndrome." Particular attention to this has been paid by Bleiker [7] and by Pippin and his associates.[8]

7. Bleiker, R.: Ear Disturbance of Temporomandibular Origin, J. Am. Dent. A. **25**:1990-1399, 1938.

8. Pippin, B. N.; Moore, T. R.; McCulloch, A. J., and Moore, S.: A Method of Repositioning the Mandible in the Treatment of Lesions of the Temporomandibular Joint, J. Am. Dent. A., to be published.

The larynx can be investigated to great advantage by the body section method of roentgenography, as has been done by Canuyt and Gunsett [9] in France, by Leborgne [10] of Montevideo and by Howes [11] and Caulk [12]

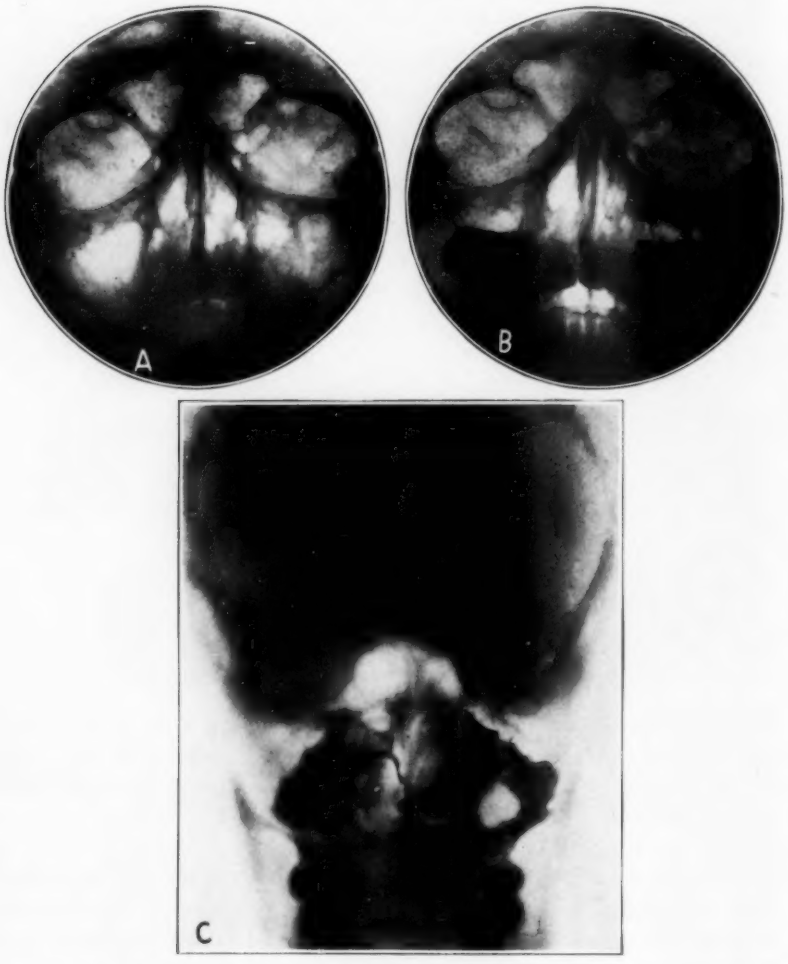


Fig. 6.—*A*, conventional roentgenogram of the paranasal sinuses, Waters position. *B*, conventional roentgenogram, Waters position, with iodized poppyseed oil in both maxillary antrums. *C*, laminagram, showing filling defect in left antrum. At operation a polyp the size of the filling defect was removed.

9. Canuyt, G., and Gunsett, A.: La tomographie ou planigraphie du larynx pathologique: Méthode des coupes ou sections radiographiques, Ann. d'oto-laryng., 1937, pp. 987-994.

10. Leborgne, F. E.: Tomography and Cancer of Larynx, Arch. Otolaryng. **31**:419-425 (March) 1940.

in this country. Mobility of the vocal cords can be investigated in different phases of phonation (fig. 7), and deviation of the air columns in the larynx, encroachment on the air passages by new growth and edema and increase in the size of the larynx through ulcerative processes can be clearly shown (fig. 8). Laminagrams are of particular value in the examination of the subglottic region, inaccessible to the laryngoscope.

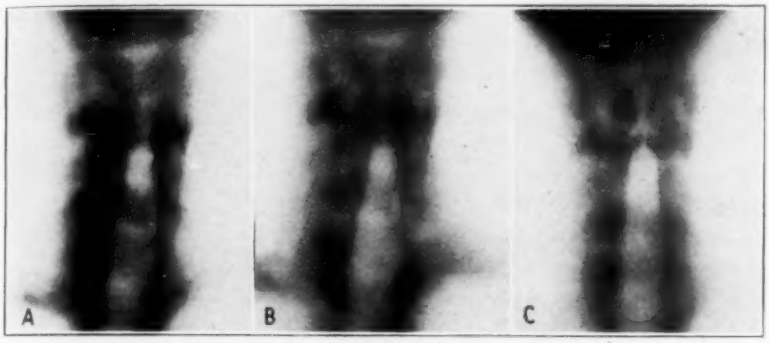


Fig. 7.—Laminagrams of the larynx, made (*A*) while the subject was breathing, (*B*) while he was holding his breath and (*C*) during phonation (E).

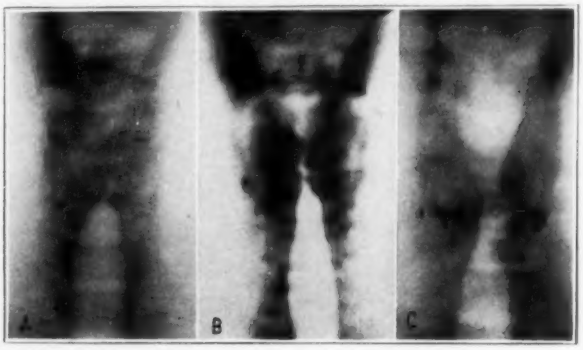


Fig. 8.—Laminagrams of the larynx. *A* shows the deviation of the air column in a patient with carcinoma of the larynx. *B* shows distortion of the air column and laryngeal stenosis in a patient with syphilis. *C* shows enlargement of the air column through ulceration in a patient with carcinoma.

Their exact clinical value in the diagnosis of conditions in the subglottic regions has not yet been established. Leborgne considered body section roentgenography to be of great value but properly stated that it should be supplemented by direct laryngoscopic examination and also by the

11. Howes, W. E.: Sectional Radiography of the Larynx, Radiology **33**:586-597, 1939.

12. Caulk: Personal communication to the authors.

lateral standard roentgenogram of the larynx. One of us (S. M.) cannot agree with him as to the importance of the latter. In our experience certainly the lateral laminagrams of the larynx have so far been valueless, probably because that structure is too great a distance from the film for this type of examination.

A brief reference should be made to the technic employed in body section roentgenographic examination of the paranasal sinuses. It is unnecessary to explain the details of the strictly roentgenographic technic, but it is important that the position of the patient and the depths at which laminagrams are taken should be made clear. The patient is placed in the prone position, with the plane of the face parallel with the top of the table. In the routine method employed for this type of examination, exposures are made at 4, 5 and 6 cm. from the plane of the face. The laminagrams thus produced show the anterior and the posterior ethmoid cells and the sphenoid sinuses. As has previously been stated, the standard roentgenogram usually suffices in the examination of the maxillary antrums, but occasionally laminagrams are needed, not only of the maxillary antrums but also of the frontal sinuses. In that event additional laminagrams are made. In the examination of the frontal sinuses these are made at distances of 0.5 cm. and 1 cm. from the plane of the face, and if the frontal sinuses have a great anteroposterior dimension an additional exposure is made at a distance of 1.5 to 2 cm. For the examination of the maxillary antrums laminagrams at 2 and at 3 cm., in addition to the routine exposure at 4 cm., are sufficient.

## DEMONSTRATIONS

Experimental work with laminagrams has demonstrated what detail can be expected with this method of study.

My associates and I have made serial laminagrams of the heads of cadavers at 1 cm. depths in lateral and anteroposterior positions. After the completion of all roentgenograms the cadavers' heads were sectioned by using a band saw at correspnding measurements and in the plane of the laminagrams.

The comparison of the laminagrams with the actual sections of the heads permits the best evaluation for body section roentgenography that can be made.

Lateral views may be of great value, as shown in the laminagram in figure 9 *E*. The sphenoid sinus in the laminagram is blurred. The section of the cadaver's head showed the sphenoid sinus to be filled with fluid and thick membrane. The ethmoid cells are clear in the laminagram and in the head of the cadaver.

The anteroposterior series of laminagrams shows at a depth of 1 cm. only the frontal sinus. I feel that at this depth the conventional frontal position is preferable.

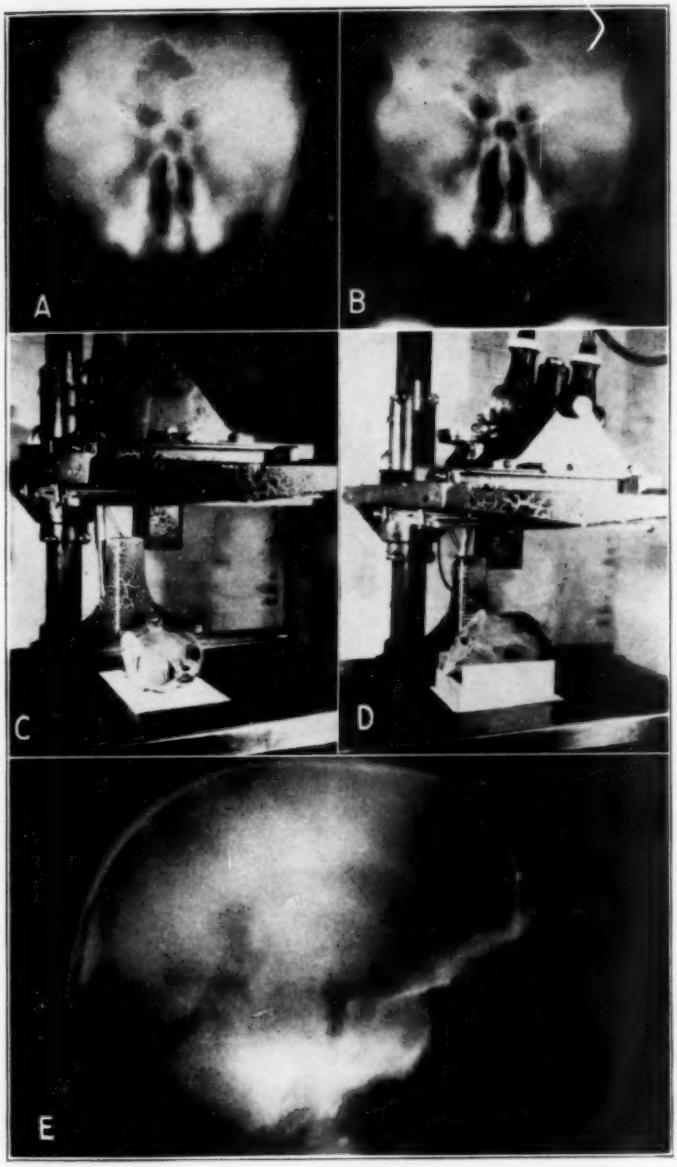


Fig. 9.—*A*, laminagram made at a depth of 1 cm., showing the frontal sinuses. *B*, laminagram made at a depth of 2 cm., showing the frontal and the fronto-ethmoid cells. *C* and *D*, photographs of a cadaver's head in position for laminagraphy. *C* shows the position for the lateral view; *D*, for the anteroposterior view. *E*, a laminagram made at a depth of 7 cm. shows clouding of the sphenoid sinus due to thickening of the mucous membrane. Note the clear posterior ethmoid cell and the sharp line of the face of the sphenoid.

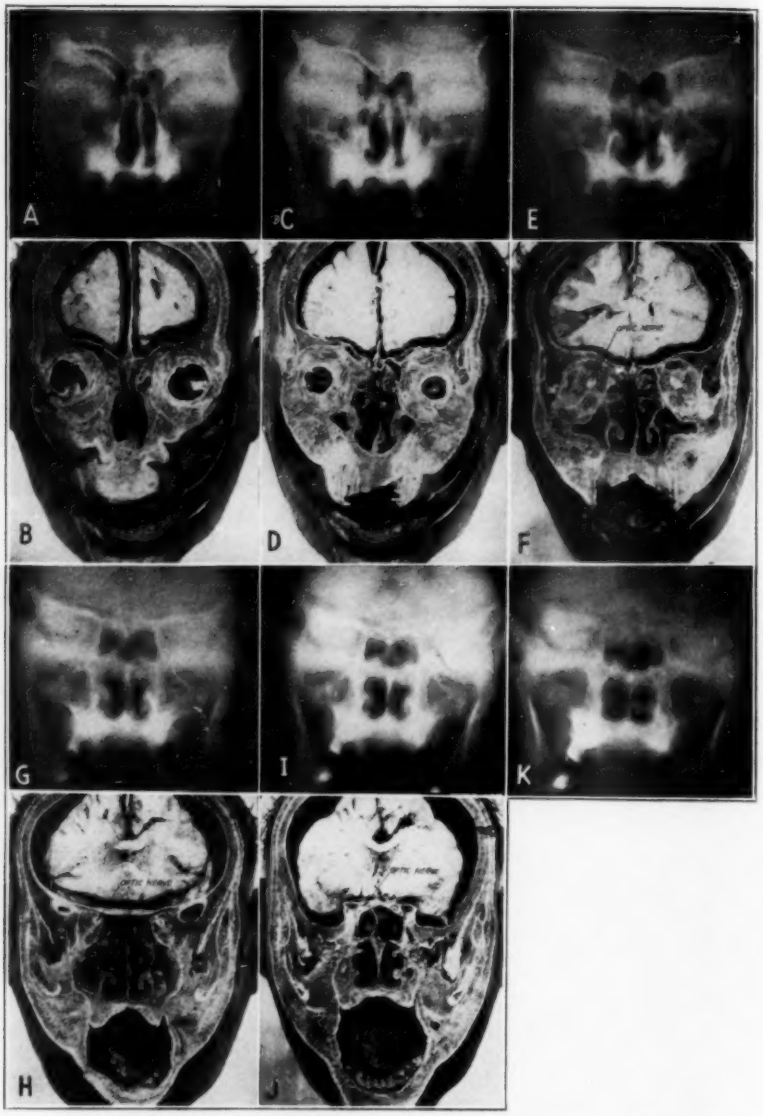


Fig. 10.—Laminagrams taken through the anterior 8 cm. of the skull. The head was sectioned with a band saw at corresponding depths, starting at 3 cm. Compare the laminagrams with the photographs. *A*, laminagram at 3 cm., showing the anterior ethmoid sinuses with orbital extensions. *B*, head sectioned at a depth of 3 cm. *C*, laminagram at 4 cm., showing the anterior ethmoid sinuses with orbital extensions. *D*, head sectioned at a depth of 4 cm. *E*, laminagram at 5 cm., showing the posterior ethmoid sinuses. *F*, head sectioned at a depth of 5 cm. *G*, laminagram at 6 cm., showing the posterior ethmoid sinuses. *H*, head sectioned at a depth of 6 cm. *I*, laminagram at 7 cm., showing the sphenoid sinuses. *J*, head sectioned at a depth of 7 cm. *K*, laminagram at 8 cm., showing the posterior limit of the sphenoid sinuses.

At 2 cm. the frontal sinuses are still in focus, and there is a suggestion of a frontoethmoid cell development. At 3 cm. the frontal development is barely discernible, and there is the sharp detail of frontal ethmoid

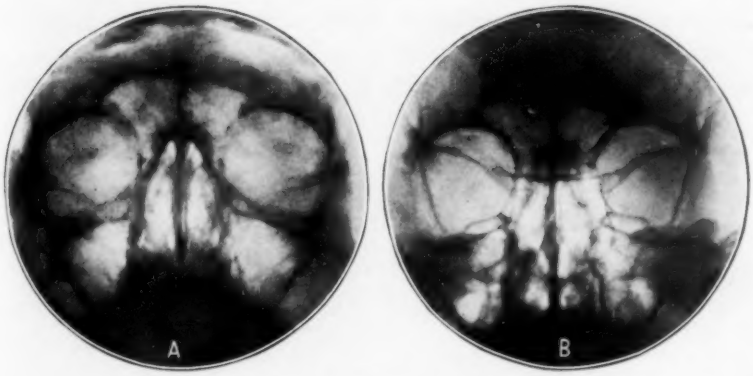


Fig. 11.—Conventional roentgenograms of a patient: *A*, Waters projection; *B*, Caldwell projection.

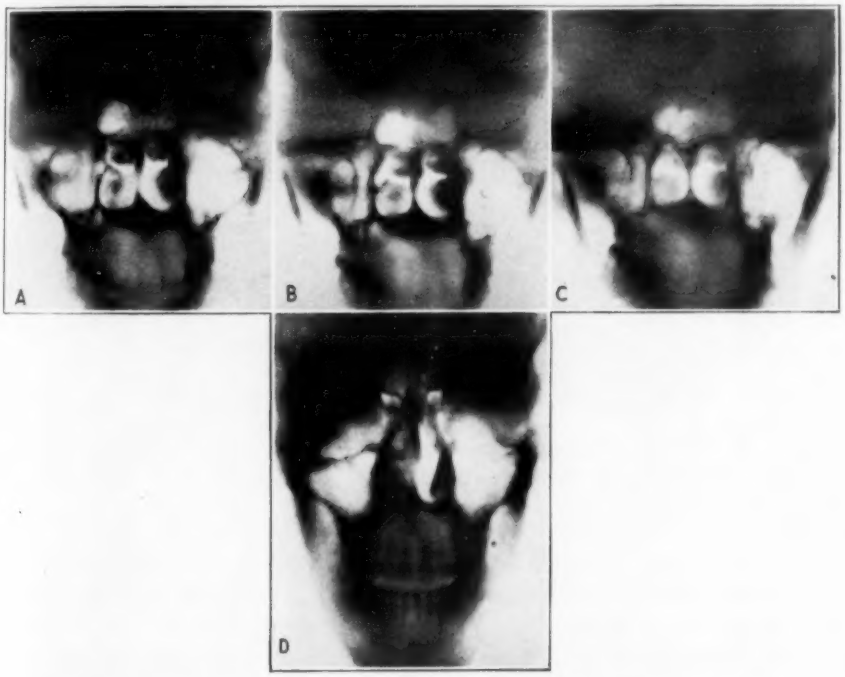


Fig. 12.—Laminagrams of the patient in figure 11, made at depths of (*A*) 5 cm., (*B*) 6 cm. and (*C*) 7 cm. *D*, laminagram made at a depth of 4 cm. Note the large cell in the middle turbinate, on the right, not visualized in the conventional roentgenogram.

cells on each side. Also note the detail of the nasal septum with its basal spur. It was at this 3 cm. depth that the first section of the cadaver's head was made.

The direct comparison of the laminagram and the sections of the heads demonstrates the possibilities of the method. At 4 cm. the frontoethmoid extensions can still be seen. The septal spur is more pronounced. At 5 cm. the frontoethmoid extension has disappeared. At

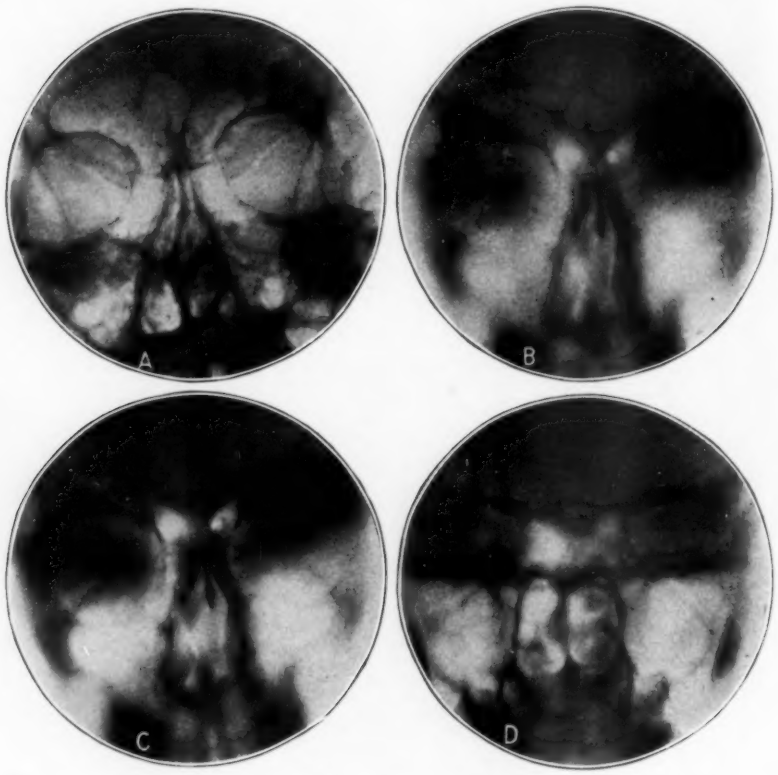


Fig. 13.—*A*, conventional roentgenogram of a patient, Caldwell projection. *B*, *C* and *D*, laminagrams of the area shown in *A*, made at depths of (*B*) 2 cm., (*C*) 4 cm. and (*D*) 6 cm.

6 cm. the region just anterior to the convex roof of the sphenoid sinus is in focus. In the section you will note the opening through the front face of the left sphenoid sinus.

The laminagram is suggestive of an inequality in the size of the sphenoid sinuses, the one on the left side being larger. At 7 cm. the comparison in detail between the laminagram and the section is clear. The sphenoid development is well shown.

Note in the cadaver specimen the irregularities in the depth of the sphenoid sinus, along the posterior wall, which are also shown in the laminagram at 8 cm. depth.

I have had a group of patients for the study of whom laminagraphy has been of particular interest, both in demonstrating anatomic variations in sinal development and in showing changes in the membranes which cannot be shown by the conventional films. I have reported previously on sinal laminagraphy as used in the study of a group of

Fig. 14.—Postoperative laminagram, made at a depth of 4 cm., of the patient in figure 13.

patients with serious ocular disorders, in whose cases the findings were of invaluable aid.

Figures 11 and 12 *A, B* and *C* illustrate in part different points of value in sectional roentgenography.

Figure 11 shows roentgenograms, made with the Waters and with the Caldwell projection, of a patient who had had headaches for years. Figure 12 shows laminagrams of the same patient. She had been carefully studied in several hospitals. The examination of her nose showed little evidence of abnormality. The clouding of the left ethmoid and

sphenoid sinuses shown in the laminagrams made at a distance of 5, 6 and 7 cm. is in striking contrast to the clear appearance in the films obtained with the Waters and the Caldwell projection. The conditions seen in the laminagram were verified at operation—extensive changes being present in both these sinuses.

The single laminagram (fig. 12 *D*) is of a patient who had had severe headaches. A submucous resection of the nasal septum was done. The films were taken to check up on the condition of his ethmoid sinuses. An

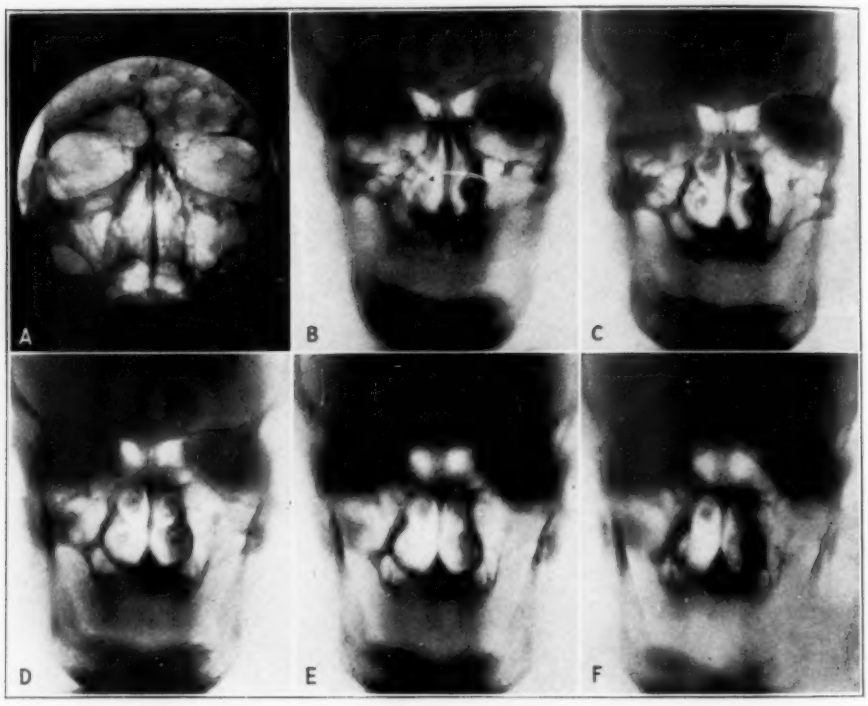


Fig. 15.—*A*, conventional roentgenogram of a patient, Waters projection. *B*, *C*, *D*, *E* and *F*, laminagrams of the patient in *A*, made at depths of (*B*) 3 cm., (*C*) 4 cm., (*D*) 5 cm., (*E*) 6 cm. and (*F*) 7 cm.

extension of an ethmoid cell into the middle turbinate was found at a depth of 4 cm. It was not visible in the exposure made at a distance of 3 cm. or the one at 5 cm.

The group of films in figure 13 illustrates particularly a large frontoethmoid extension becoming visible at a depth of 2 cm. Marked thickening and deviation of the septal cartilage are seen at varying depths and the large frontoethmoid extension is visible at a depth of 4 cm.

At 6 cm. there is blurring of the left sphenoid sinus. The chief complaint of the patient had been headache.

A submucous resection of the nasal septum was done. The laminagrams taken at a depth of 5 cm. show well the improvement in the anatomic relationship of the nasal septum to the turbinates.

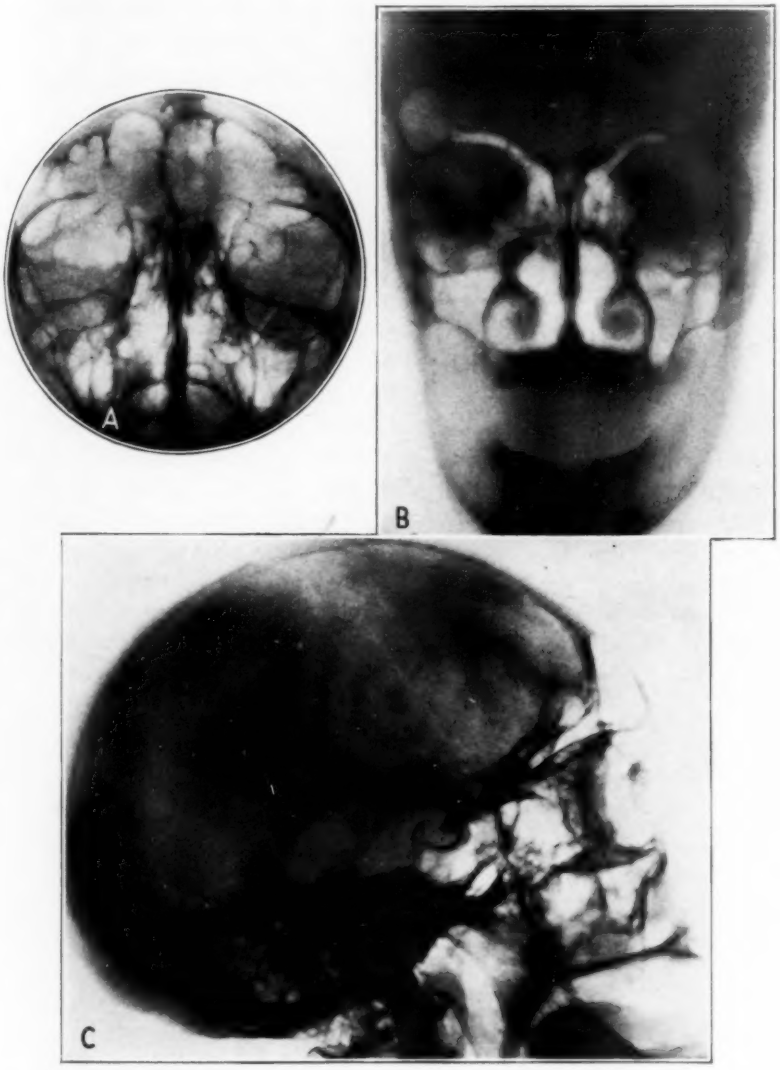


Fig. 16.—*A*, conventional roentgenogram of a patient, Waters projection. *B*, laminagram of the same patient, made at a depth of 4 cm. *C*, lateral roentgenogram of the skull of the patient.

The group of films in figure 15 includes a roentgenogram made with the conventional Waters projection and a series of laminagrams made at depths of 3, 4, 5, 6 and 7 cm. Variations may be noted at

each difference in depth. The Waters projection suggests great cellular variation, but no detail is visible.

Note the supraorbital and antral extensions of ethmoid cells at 3, at 4 and at 5 cm. At 6 cm. the convex line which identifies approach to the sphenoid sinuses is seen. There is a posterior extension of an ethmoid cell apparently encroaching on the sphenoid sinus.

At 7 cm. (*F*) the sphenoid sinus is visible; the roof is sharp and clear. The lateral extension is seen.

The last group of films (fig. 16) includes a roentgenogram made with the Waters projection, a laminagram made at a depth of 4 cm. and a lateral roentgenographic view of the skull. They are films of an elderly patient who had incapacitating headaches for seven years. Previous intranasal operations had been done, and the patient had been told that the condition of the sinuses could not be a cause for her headache. A period of allergic control did not give relief.

The extreme sinal development is apparent in the Waters projection and in the lateral roentgenogram. All details of development were shown best in a series of laminagrams. The most striking change was noted in the laminagram made at a depth of 4 cm. At operation the nasofrontal duct was found to be blocked, and the entire cellular area of this supraorbital extension had no adequate drainage or ventilation. The patient's condition has been improved by surgical intervention by external frontal and ethmoid approach.

# ACUTE LARYNGOTRACHEOBRONCHITIS

## REPORT OF A CASE AND REVIEW OF THE LITERATURE

REUBEN KAYSER, M.D.
BROOKLYN

The recognition of acute laryngotracheobronchitis as a clinical entity is a step in the direction of saving many young patients whose condition would otherwise be considered hopeless. The terrifying urgency of the inspiratory and expiratory difficulty experienced by an infant suffering with acute laryngotracheobronchitis calls for active intervention.

When a physician is called to treat a croupy infant with a negative Schick reaction, with no abnormal signs in the chest and with little or no elevation of temperature, adequate therapeutic measures consist of the administration of nasal drops and a mild expectorant and inhalations of compound tincture of benzoin steam. Should the throat appear red and congested, sulfanilamide may be employed even before the result of culture of material from the throat is reported. But if there seems to be increasing laryngeal obstruction and the therapeutic measures in no way arrest the progress of the obstruction, the physician must of necessity realize that he has an urgent problem on hand. The problem must be met within a matter of hours or even of minutes.

Otherwise, as Lyman Richards [1] said, "The pediatrician and general practitioner still mistake the condition for diphtheria, spasmodic croup or some other milder form of laryngeal obstruction, with the result that these patients at times arrive at the hospital either as obstructive emergencies or in so toxic and exhausted a state as to render the hope of recovery a tragically forlorn one."

Particularly to the initial interest of Chevalier Jackson,[2] T. R. Gittins [3] and others, as well as to the work and inspired writings of

1. Richards, L.: A Further Study of the Pathology of Acute Laryngotracheobronchitis in Children, Ann. Otol., Rhin. & Laryng. **47**:326-341 (June) 1938.

2. Jackson, C., and Jackson, C. L.: (*a*) Acute Laryngotracheobronchitis, J. A. M. A. **107**:929-932 (Sept. 19) 1936; (*b*) Acute Laryngotracheobronchitis, in Bronchoscopy, Esophagoscopy and Gastroscopy, Philadelphia, W. B. Saunders Company, 1934, p. 311.

3. Gittins, T. R.: (*a*) Laryngitis and Tracheobronchitis in Children: Special Reference to Non-Diphtheritic Infection, Ann. Otol., Rhin. & Laryng. **41**:422-438 (June) 1932; (*b*) Laryngitis and Tracheobronchitis: Reference to Nondiphtheritic Infections, ibid. **45**:1165-1174 (Dec.) 1936; Tr. Am. Bronchoscopic Soc. **5**:122-132, 1936.

Richards,[4] Baum,[5] Brennemann and his associates,[6] Neffson and Wishik,[7] Tolle[8] and others, is credit to be given for the hope and direction they extend to the physician confronted with such a case. Brennemann and his associates[6] (p. 681), in discussing the treatment of such an entity, confessed that at first they were "bewildered and worried." With the cooperative attitude of the laryngologist and the pediatrician and with unremitting and meticulous vigilance by trained assistants, the mortality resulting from this disease can be reduced from a reported average of 54 per cent to 25 per cent or less.

It is generally agreed that in cases of true acute laryngotracheobronchitis, instrumental intervention is imperative. This may be bronchoscopic examination and suction, intubation, tracheotomy and suction or any combination of these. What is the mechanism necessitating instrumental intervention so urgently? Can it be, first, that there is a confusion of nomenclature, which causes delay and makes of what should have been an elective, orderly operation an urgent emergency treatment instead? Neffson and Wishik[7] directed attention to the number of names which make the nomenclature associated with this entity so confusing. They mentioned "acute catarrhal croup," "acute laryngitis," "acute nondiphtheritic croup," "acute obstructive nondiphtheritic laryngitis," "streptococcic laryngotracheitis," "septic laryngitis" and others. Jackson and Jackson[2] classified this condition under the name "edematous tracheobronchitis." They said that it is the sporadic form of the influenzal or epidemic acute laryngotracheobronchitis. Richards[9] discussed "a fulminating laryngotracheobronchitis." He defined it[4a] as

> An acute infection of the upper respiratory tract, characterized by a high febrile reaction, and an intense inflammatory change in the mucous membrane and walls of the trachea, bronchi and bronchioles and accompanied by the formation of a sticky, gummy, often glue like exudate or secretion, partially or completely occlud-

4. (*a*) Richards, L., and Farber, S.: Fulminating Laryngotracheobronchitis, Ann. Otol., Rhin. & Laryng. **42**:1014-1040 (Dec.) 1933; (*b*) Types of Laryngeal Obstruction and Their Treatment, Am. J. Surg. **42**:239-259 (Oct.) 1938. Richards.[1]

5. Baum, H. L.: (*a*) Some Endoscopic Observations on Laryngotracheobronchitis, Ann. Otol., Rhin. & Laryng. **33**:782-788 (Sept.) 1924; (*b*) Acute Laryngotracheobronchitis, J. A. M. A. **91**:1097-1102 (Oct. 13) 1928.

6. Brennemann, J.; Clifton, W. M.; Frank, A., and Holinger, P.: Acute Laryngotracheobronchitis, Am. J. Dis. Child. **55**:667-695 (April) 1938.

7. Neffson, A. H., and Wishik, S. M.: Acute Infectious Croup: A General Study of Acute Obstructive Infections of the Larynx, Trachea and Bronchi, with an Analysis of Seven Hundred and Twenty-Seven Cases. II. Acute Non-Specific Infectious Croup, J. Pediat. **5**:617-641 (Nov.) 1934.

8. Tolle, D. M.: Croup: Analysis of Three Hundred and Forty-Four Cases, Am. J. Dis. Child. **39**:954-968 (May) 1930.

9. Richards.[1] Richards and Farber.[4a]

ing the upper airways. The occluding secretion may extend upward to become attached to the glottic walls or the infection may proceed downward to fill the terminal bronchioles and alveolae and hence to produce a bronchopneumonia.

It seems that a proper appreciation of the appropriateness of the term "acute laryngotracheobronchitis" for this clinical entity, as well as an appreciation of the mechanism of obstruction, can be induced by a consideration of the alteration in the normal anatomy caused by the disease.

### NORMAL ANATOMY

As this is a disease most frequently seen in infants and young children, it is necessary first to describe the normal anatomy of the structures involved, namely, the larynx and airway. In infancy the larynx is comparatively small. It is rich in vascular channels. The lymphatics of the larynx and trachea are extremely abundant—except at the vocal cords, where they are absent. The lymphatics of the supraglottic and the infraglottic area communicate only at the narrow posterior interarytenoid area. The mucosa of the larynx and the trachea is a pseudostratified ciliated epithelium—except that portion covering the vocal cords, which is stratified columnar. This epithelium rests on a distinct basement membrane, underneath which is loose submucosa-supporting connective tissue. This tissue is particularly loose in the subglottic area, the site of the conus elasticus, where the laxity is macroscopic. The submucosa contains numerous seromucous glands, both in the larynx and in the trachea. It also contains numerous arteries and veins and tributaries. Usually the vocal cords, because of their lack of lymphatics, form a barrier to supraglottic edema or lymphatic drainage to the infraglottic areas. In acute laryngotracheobronchitis, the posterior wall of the larynx gives adequate passage for the extension of the infection and the inflammatory process.

### PATHOLOGIC ANATOMY AS OBSERVED IN LIVING SUBJECT

To appreciate acute laryngotracheobronchitis in an infant, therefore, whose larynx and glottic chink are comparatively small and narrow, one has to visualize the changes caused in the normal anatomy by an intensely acute inflammatory process. The reaction of an infant's larynx, trachea and bronchi to such an acute infection is marked. Neffson and Wishik [7] described the pathologic alterations in the living infant substantially as follows:

Edema. This occurs above and below the true vocal cords, with extreme red swelling of the epiglottis, aryepiglottic folds and false cords preventing visualization of the true vocal cords.

Exudation. This depends on the severity and stage of the condition. First, the exudate is seromucous. Then it becomes seropurulent. Should the condition progress, the exudate becomes ropy, thick and tenacious.

Membrane. Where present, its consistency is constant, instead of becoming firmer, as in diphtheria.

Jackson and Jackson [2b] (p. 311) noted that bronchoscopic examination shows the

influenzal infection to be characterized by intense reddening and swelling of the mucosa. Hemorrhagic spots and superficial erosions are commonly seen, and a thick tenacious exudate, difficult to expectorate, lies in patches in the trachea. Infants may asphyxiate from accumulation of this secretion which they are unable to expel.

Therefore, the process is an acute inflammatory one, definitely of the larynx, trachea, bronchi and bronchioles. It produces redness and edema. This is followed by exudation, at first seromucoid, then seropurulent. It is to be noted that the secretions and activity of the glands in acute laryngotracheobronchitis are in contrast with the subnormal activity of the laryngeal and tracheal glands in diphtheria. Brennemann and his associates [6] and Councilman, Mallory and Pearce [9a] noted that the early glandular necrosis in diphtheria, with little damage to the surrounding tissue, is in contrast to the early freedom from glandular damage in acute laryngotracheobronchitis. They expressed the belief that the soluble toxin produced in diphtheria causes the suppression and necrosis of the glands. Farber [4a] summarized the pathologic changes as diffuse cellular infiltration with destruction of the walls of the larynx, trachea and bronchi. He, as well as Brennemann and his associates,[6] described the surface fibrinous and fibrinopurulent exudation with destruction and masking of the epithelium. Brennemann and his associates [6] noted that it is apparently the mixture of mucus, fibrin, polymorphonuclear leukocytes and the degenerated epithelial cells which makes the typical gummy, ropelike exudate and crusts. Richards [1] noted that there is destruction of the mucosal surfaces, with the desquamated epithelium forming the nucleus of a membrane. This membrane acts like a foreign body, and this further diminishes the size of the already restricted airways. Gittins [3a] described the characteristic pathologic changes as "consisting of subglottic swelling and thick discharge in the trachea and bronchi, which has tended to form in masses and plugs. Thin gray exudate over thickened mucosa, rather than membrane, has been usual." Terminally there may be complete necrosis of the mucosal secreting surface, leaving only a dry glazed lining of the tracheal and bronchial tree. Accompanying the partial or complete obstruction of the bronchi, there may be emphysema, atelectasis, pneumonia, or spontaneous pneumothorax from rupture of an emphysematous bleb.

9a. Councilman, W. T.; Mallory, F. B., and Pearce, R. M.: A Study of the Bacteriology and Pathology of Two Hundred and Twenty Fatal Cases of Diphtheria, J. Boston Soc. M. Sc. **5**:139-319 (Dec. 18) 1900.

HISTORICAL AND BIBLIOGRAPHIC NOTES

The French physician, Blaud,[9b] discussed acute laryngotracheobronchitis one hundred years before the discovery of the diphtheria bacillus. In 1915, Strachen [10] reported 3 cases of acute septic tracheitis with 100 per cent mortality.

As early as 1920, Gittins [3b]

> realized for the first time that there were cases of serious laryngitis and tracheobronchitis in young children in which the onset and clinical picture simulated diphtheria, but in which antitoxin gave no relief and mechanical obstruction below the cannula was decidedly more troublesome than in true diphtheria.

Since then he has been doing missionary work in the investigation and treatment of this disease. By 1936, he had reported [3b] 32 cases in which there was serious obstructive dyspnea; 20 patients had tracheotomy, among whom 12 died, a mortality of 60 per cent. In 1924, Lynch [11] reported 5 cases in which the involvement was mild, with all the patients recovering from an "exudative tracheobronchitis with obstructive dyspnea." Baum,[5] in 1924 and again in 1928, presented a series of 22 cases in which intubation proved to be of great therapeutic value. In 1924, Clerf [12] reported 17 life-saving bronchoscopic aspirations undertaken in cases in which there was obstructive dyspnea.

In 1927, Tucker [13] showed movies of a patient with obstructive dyspnea. He emphasized the importance of relieving the obstructive dyspnea first and making the diagnosis later. In discussing Tucker's paper, A. W. Proetz spoke in favor of a deliberate elective operation.

In 1928, Berry [14] reported a case of membranous laryngitis and tracheitis in an adult. C. Jackson [2] has contributed much to the understanding and therapy of both the disease and its complications.

In 1929, Mainzer [15] reported a case of acute laryngotracheobronchitis, with tracheotomy and death; autopsy showed a plug completely obstructing the left bronchus.

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9b. Blaud, cited by Jackson and Jackson,[2b] p. 311.

10. Strachen, J. G.: Acute Septic Tracheitis, Canad. M. A. J. **15**:708-710 (July) 1915.

11. Lynch, R. C.: Potpourri, Laryngoscope **34**:753-757 (Oct.) 1924.

12. Clerf, L. H.: Seventeen Life Saving Bronchoscopies in One Case, Surg., Gynec. & Obst. **38**:472-474 (April) 1924.

13. Tucker, G.: (*a*) Obstructive Laryngeal Dyspnea, Tr. Am. Laryng., Rhin. & Otol. Soc. **33**:324-331, 1927; (*b*) The Infantile Larynx: Direct Laryngoscopic Observations, J. A. M. A. **99**:1899-1902 (Dec. 3) 1932.

14. Berry, G.: Membranous Laryngitis and Tracheitis with Staphylococcus Aureus Hemolyticus Infection, Tr. Am. Bronchoscopic Soc. **1**:34-37, 1938.

15. Mainzer, F. S.: Acute Laryngotracheobronchitis, Pennsylvania M. J. **33**: 24 (Oct.) 1929.

In 1930, Myerson [16] reported his experiences with tracheotomy. He cited 1 case in which delay incidental to making a diagnosis also delayed the therapy necessary. Tolle,[8] in 1930 and on later occasions, after analyzing the cases at the Willard Parker Hospital, expressed partiality for suction, done through a laryngoscope, a bronchoscope or a tracheal cannula.

Phelps,[17] in 1932, recommended tracheotomy as an initial procedure. In 1932, Thenebe,[18] reporting a series of 51 cases, in 28 of which mechanical relief was required, expressed his opinion in favor of early instrumental intervention. Johnson [19] reported 3 cases; he favored tracheotomy.

In 1934, Neffson and Wishik [7] reviewed 727 cases of acute laryngitis and reported 84 in which mechanical intervention was required; 22 were cases of acute laryngotracheobronchitis. The respective merits of intubation and tracheotomy, as well as indications for the use of suction through a tube, were discussed by these authors.

In 1935, Kully [20] reported 31 cases of severe obstructive dyspnea, in 9 of which it was nondiphtheritic. Kully expressed his preference for tracheotomy.

In 1936, Smith [21] reported 43 cases of nondiphtheritic obstructive dyspnea, in 12 of which tracheotomy was required. Four of the patients on whom tracheotomy was performed died.

Holinger,[22] in 1937, expressed himself in favor of tracheotomy, after discussing this subject. Howard,[23] in 1938, reported 63 cases of obstructive dyspnea in which mechanical intervention was necessary to relieve the laryngeal obstruction; in 29 of these the condition was diphtheritic and in 34 it was nondiphtheritic. Howard reached the conclusion that intubation was the procedure of choice. Brennemann and his associates,[6] in 1938, reported a series of cases observed by them

16. Myerson, M. C.: Tracheotomy: Some Observations and Experiences, Ann. Otol., Rhin. & Laryng. **39**:563-577 (June) 1930.

17. Phelps, K. D.: Laryngeal Emergencies in Infants and Children, Minnesota Med. **15**:227-234 (April) 1932.

18. Thenebe, C. L.: Acute Non-Diphtheritic Laryngeal Obstruction, New England J. Med. **207**:740-742 (Oct. 27) 1932.

19. Johnson, M. C.: Acute Laryngotracheobronchitis in Children, Arch. Otolaryng. **17**:230-234 (Feb.) 1933.

20. Kully, H. E.: Tracheotomy for the Relief of Laryngeal Obstruction in Children, Arch. Otolaryng. **22**:317-324 (Sept.) 1935.

21. Smith, W. J.: Acute Laryngotracheitis in Children, Arch. Otolaryng. **23**: 420-428 (April) 1936.

22. Holinger, P. H.: Acute Laryngotracheobronchitis in Infants, J. Michigan M. Soc. **36**:969-972 (Dec.) 1937.

23. Howard, W. A.: The Use of Intubation and Tracheotomy in the Treatment of Obstructive Laryngitis in Children, J. Pediat. **12**:47-57 (Jan.) 1938.

from 1927 to 1936, inclusive. Of 129 patients with obstructive dyspnea, 84 were treated by palliative measures; the remaining 45 had difficulties severe enough to require instrumental intervention. The authors expressed opinion that these 45 had true acute laryngotracheobronchitis. To Richards [4] much credit is due for his experimental work on tracheal wounds. He has repeatedly directed attention to this entity. In 1938 he reported a series of 17 cases of acute fulminating laryngotracheobronchitis. He pointed out that he was enthusiastically in favor of tracheotomy and postoperative bronchoscopic treatment when indicated. Brennemann and his associates [6] expressed their preference for tracheotomy as the means of giving mechanical relief.

Negus,[24] in 1938, contributed much to a sound understanding of the asphyxia attendant on the obstructive dyspnea present in this disease. He said: "If the stridor is noticeable when the patient is resting, the patient is in the danger zone. If the stridor is audible when the patient is asleep, the operation (tracheotomy) is urgently required."

C. L. Jackson,[25] in 1938, brought the picture of acute laryngotracheobronchitis as a clinical entity of great seriousness up to date.

Graebner,[26] in 1939, reviewed 20 cases of nonspecific croup encountered at the Willard Parker Hospital and presented 2 cases of pneumopericardium and 3 cases of pneumomediastinum.

Michels,[27] in 1939, recorded 6 cases of acute laryngeal obstruction, with a mortality of 50 per cent.

Cassidy,[28] in 1939, recorded the case of an infant on whom 37 bronchoscopic aspirations were done over a period of thirteen days following tracheotomy; the case resulted in cure.

Evans,[28a] in 1939, reported the cases of 3 patients who recovered from acute laryngotracheobronchitis. He stressed the early formation in the cases in which the disease was due to Staphylococcus of thick tenacious dirty gray mucous plugs and crusts covering the cords and rapidly causing marked progressive obstructive symptoms.

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24. Negus, V. E.: An Explanation of the Respiratory Failure Sometimes Occurring After a Successful Tracheotomy, Ann. Otol., Rhin. & Laryng. **47**:608-614 (Sept.) 1938.

25. Jackson, C. L.: Acute Laryngotracheobronchitis in Children, M. Clin. North America **22**:1581-1590 (Nov.) 1938.

26. Graebner, H.: Pneumopericardium and Pneumomediastinum in Cases of Acute Obstructive Laryngitis, Arch. Otolaryng. **29**:446-456 (March) 1939.

27. Michels, M. W.: Pneumothorax and Mediastinal Emphysema Complicating Tracheotomy, Arch. Otolaryng. **29**:843-852 (May) 1939.

28. Cassidy, W. A.: Acute Laryngotracheobronchitis, Arch. Otolaryng. **29**: 857-859 (May) 1939.

28a. Evans, M. G.: Acute Laryngo-Tracheo-Bronchitis: Report of Three Recovered Cases, Ann. Otol., Rhin. & Laryng. **48**:216-226 (March) 1939.

ETIOLOGY

Acute laryngotracheobronchitis, with its obstructive respiratory entity, is most common in infants up to 2 years of age. It is fairly common in children under the age of 5 years. It has been reported occurring in children up to 15 years of age. Gittins [3b] reported its occurrence in an adult. Berry [14] reported it as a complication of pregnancy.

Holt [29] observed that the disease is more common among children who are well nourished. With diphtheria the opposite is the case (Eschenbrenner [30]).

In all the reported series of cases there is a preponderance of male patients. Howard's [23] series had 82 per cent males in the group in which the condition was nondiphtheritic. Gittins did not stress the age-sex factor. Seventy-two per cent of Neffson and Wishik's [7] 22 cases were those of males. It may be noted here that this is in contrast with the observations made in the cases in which the condition was diphtheritic, in the majority of which the patients were females.

Tolle [8] noted that the months of greatest frequency of this disease are March, April, October and November. Kully [20] added to these months December, January and February. The sudden changes of temperature occurring during these months are predisposing factors.

There may be a yearly variation in the incidence and severity of the disease. Gittins stated that he had not encountered the condition in epidemic form. The 32 cases he observed occurred 1 at a time, in contrast to the incidence of diphtheria. Lynch [11] reported 5 cases occurring in one month.

Gittins [3b] stated that in many of the serious cases of laryngitis and tracheitis among infants and young children the condition is caused by infections contracted by contact with older children or adults who are suffering from comparatively mild and ambulatory types of respiratory infection. Kully [20] added that laryngeal obstruction is found in association with such general diseases as measles, scarlatina, typhoid, pneumonia, smallpox and pertussis.

Jackson,[25] Gittins,[3] Baum [5] and others reported the aspiration of a vegetable foreign body as an etiologic factor in cases of acute laryngotracheobronchitis. In 4 of Baum's 24 cases the condition was due to the presence of a vegetable foreign body in the lung, namely, a peanut, a grain of popcorn, a watermelon seed or a bean. In 3 of Gittins' cases the obstruction was due to a foreign body. Gittins stated that it seemed

29. Holt, L. E.: Disease of Infancy and Childhood, ed. 7, New York, D. Appleton and Company, 1911.

30. Eschenbrenner, J.: The Treatment of Laryngeal Diphtheria: A Statistical Study of Six Hundred and Fifty-Five Cases, Ann. Otol., Rhin. & Laryng. **45**: 485-495 (June) 1936.

reasonable to assume that the patient was suffering from an infection of the upper respiratory tract at the time of inhalation of the foreign body. He added: "Undoubtedly many of these patients are lost after bronchoscopy because proper efforts are not made to insure good postoperative plumbing of the lower air passages." It may be added here that Gittins repeatedly emphasized the fact that experience teaches that the diagnosis of serious dyspnea is the important thing, regardless of the cause.

Neffson and Wishik,[7] in analyzing the bacteriologic findings, reported, in the order of frequency of occurrence, Streptococcus haemolyticus, Streptococcus viridans, Staphylococcus aureus and Bacillus influenzae. Baum [5] added that 2 of his patients had pneumococci. In Howard's [23] series of cases Str. viridans was the most common organism isolated. Howard also reported the presence of Staphylococcus albus.

Kully [20] noted that the inhalation of boiling steam and liquids or the drinking of scalding or corrosive fluids may cause acute obstructive symptoms.

The presence of enlarged tonsils is reported by most observers. Holt [29] noted that an enlarged uvula is usually found.

## SYMPTOMS

There is a regular order of appearance of symptoms. As noted by Baum,[5] the disease is usually ushered in by an attack of acute rhinitis and pharyngitis of from several hours' to a few days' duration. There is coryza, accompanied by a cough which is croupy, phonic, nonproductive and, from the onset of the disease, distressing. At the onset the disease is usually afebrile. Howard [23] stressed the irritability present from the onset. Gittins [3b] stated:

> Usually these little patients have had no acute infection in the tonsils, pharynx, nose or sinuses of any severity. Often they were up and about, with mild respiratory symptoms until croupy cough, dyspnea and an emergency developed over night.

According to Neffson and Wishik,[7] the onset of the dyspnea is sudden and at times catastrophic. Brennemann and his associates stressed the point that usually when the child comes under medical observation the condition has progressed to one of a severe respiratory infection, with laryngeal and obstructive symptoms as the outstanding features. Respiratory difficulty becomes the chief complaint and is present in every case. The respirations are rapid and labored. There is an inspiratory stridor, commonly an expiratory wheeze, marked hoarseness—as shown in the speech and in the cry—and, rarely, aphonia. There is a difference in the reported opinions as to the time of appearance of the hoarseness. Neffson and Wishik [7] expressed the opinion

that in the cases of nondiphtheritic obstructive dyspnea the hoarseness appears after the obstruction becomes manifest, whereas the hoarseness precedes the respiratory embarrassment in cases of diphtheria. Howard [23] directed attention to the fact that in both types of laryngeal obstruction, diphtheritic as well as nondiphtheritic, hoarseness preceded the onset of difficult breathing.

One cannot stress too much the external evidences of the severe dyspnea appearing in these cases. As early as 1920 Gittins [3b] realized for the first time that

> there were cases of serious laryngitis and tracheobronchitis in young children in which the onset and clinical picture simulated diphtheria, but in which antitoxin gave no relief and mechanical obstruction below the cannula was decidedly more troublesome than in true diphtheria.

Tucker [13] spoke of the pathognomonic symptoms of obstructive laryngeal dyspnea. He mentioned the characteristic indrawing at the suprasternal notch, around the clavicles, in the intercostal spaces and in the epigastrium. Ritchie and Gardiner [31] noted that in some of their cases the sternum was drawn in to the vertebrae. Brennemann and his associates [6] noted that even the sides of the thorax are drawn in. Baum [5] emphasized the severe physical strain of breathing through an obstructed airway.

A vital syndrome such as this occurring in exhaustive dyspnea is of necessity accompanied by restlessness. Kully [20] said:

> There is an anxious facial expression, as though the patient is conscious of impending danger, noticeable even in a very young infant. Restlessness is always present and when caused by air hunger is an indication for surgical intervention.

Restlessness continues to the point of exhaustion, when the child may become very quiet. This is an ill omen and is not to be interpreted as evidence of improvement in the child's condition.

The cough continues throughout. It is usually nonproductive. Gittins noted: "It has always seemed remarkable to me that one finds so much thick discharge at tracheotomy, even when there seemed to be symptomatic evidence of only laryngeal involvement." Later, as pointed out by Jackson and Jackson,[2] the cough reflex may become benumbed or absent. Gittins,[3b] in addressing the American Bronchoscopic Society, said:

> We in this specialty must wonder and speculate in how many of the great number of young adults with bronchiectasis, the primary insult to the bronchial and lung tissue came about because there was insufficient drainage of the lower air passage during an attack of laryngotracheobronchitis at an age when the small larynx with its subglottic swelling and the lack of cough combined to prevent proper drainage.

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31. Ritchie, J. H., and Gardiner, I. V.: Streptococcal Laryngitis, South African M. J. **9**:46-47 (Jan. 26) 1935.

Of the cyanosis appearing in acute laryngotracheobronchitis he said:[3b]

> Again, the cyanosis of rather sudden laryngeal obstruction is dramatic and self evident. It spells an emergency to anyone in charge of the patient and measures are immediately taken to relieve it or to call for help. On the other hand, the pale cyanosis, restlessness, high fever, dehydration and weak pulse, so consistent with obstruction of the smaller bronchial divisions with possible atelectasis, are not dramatic and certainly are not recognized as obstructive symptoms by the rank and file of medical men. The symptoms are considered secondary to toxemia because of the severity of the pneumonic infection.

Brenneman and his associates[6] said "there is usually some cyanosis, which is especially evident in the nails and lips." Ritchie and Gardiner[31] noted that

> in these cases of marked obstruction, pallor, instead of cyanosis, occurred and just before death, mauve veins in spider-like formations appeared on the cheeks, while the fingers and toes were markedly pale; during this stage, spasms of frantic agonizing struggles were the order until exhausted.

Kully[20] stated:

> Cyanosis is a dangerously late symptom and may be entirely absent in children. When cyanosis appears the chances for life are very poor. One should never wait until the child becomes blue before relieving the obstruction.

Neffson and Wishik[7] reported that many patients have definite remissions of one day or more, during which there may be no respiratory difficulty whasoever. In such patients, as well as in those without remissions, the stertor and dyspnea become worse at night.

*Physical Examination.*—There is usually coryza. Early the discharge is watery; it becomes mucopurulent. The tonsils are usually present, enlarged and congested. The uvula is usually enlarged and congested. The pharynx may be red.

Auscultation of the chest reveals a sharp inspiratory stridor. Expiration is accompanied by a wheeze. Large rhonchi and rales, originating in the throat or in the large bronchi, are heard. There is always evidence of difficulty in getting air into and out of the lungs. The air may enter every part of the lungs, there being little change in the character of the breath sounds.

When the air enters every part of the lungs there is little change in resonance. There may be a sudden startling change in the condition of the patient either before or after instrumental intervention. As pointed out by Brennemann and his associates, one then finds an area or

> areas of dulness to percussion, together with suppression or absence of breath sounds, or bronchial breathing and bronchophony, as atelectasis occurs owing to the complete plugging of a bronchus with the characteristically thick, tenacious gummy exudate. If a main bronchus is occluded, there will be greater restlessness, cyanosis and air hunger. To the dulness and to the suppression or absence

of breath sounds will then be added a notable shift of the heart toward the affected side and an increase of breath sounds and possibly of resonance on the opposite side. This shift is more easily recognizable if the occlusion of the main bronchus is on the right side. The cardiac tones are then heard with greater intensity to the right of the sternum than to the left. . . . More rarely, the heart may be pushed away from the affected side if there is obstructive emphysema due to partial blocking of a main bronchus. . . . The pathogenesis of these signs is confirmed by the fact that all of them may be relieved by aspiration of the obstructing exudate, which is followed by prompt return of the heart to its normal position and by relief of the more alarming dyspnea.

This therapeutic measure and problem will be further discussed under the heading of treatment.

Some investigators have reported their patients to be afebrile. Lynch's [11] 5 patients were such. Eight of Ritchie and Gardiner's 10 patients had no elevation of temperature. The temperature may range from 99.5 to 106 F. Neffson and Wishik [7] noted that the febrile reaction is higher than in the diphtheritic condition. Richards' [1] cases of fulminating laryngotracheobronchitis were characterized by a high febrile reaction. Gittins [3b] mentioned the presence of a high temperature. There is usually a marked rise of several degrees in temperature after tracheotomy. Baum [5] explained this rise in temperature as due to the improved oxgenation following instrumental improvement of pulmonary ventilation. Brennemann and his associates [6] reported a range of temperature from 102 to 104 F. Baum reported a range from 102 to 105 F.

*Laboratory Findings.*—Leukocyte Count: According to Howard,[23] the leukocyte count varies from 11,000 to 36,000, with an average of 18,600. He compared this to the average of 14,900 in diphtheritic cases. There is no relationship between the blood count and the age of the patient or the day of illness. Baum [5] reported leukocyte counts varying from 9,400 to 33,000.

Blood Culture: A positive culture of the blood is of value in diagnosis. Baum, in discussing Gittins' [3b] paper, said:

In my own cases the streptococcus has been the predominating organism, although a variety of other organisms have been recovered both by myself and by other investigators. The disease occurs mostly during epidemics of respiratory tract infections, and I am inclined to believe that the basic cause is the filtrable virus of influenza, which in these cases causes a violent inflammatory reaction in the subglottic and tracheobronchial membranes and lays the ground work for rapid subsequent invasion by the ever present streptococcus. While I have not as yet had a chance to try the treatment, it is my present intention, at my first opportunity, to use influenzal convalescent human serum in addition to the other measures outlined.

Urinalysis: The findings are similar to those in any similar toxic disease.

*Roentgen Examination.*—Roentgen examination is of value in the differential diagnosis necessary on occasion. It is of particular value

in the diagnosis of the complications, such as atelectasis, bronchial obstruction and the accompanying heart shift. Pneumothorax following emphysema, a complication which, according to Richards,[4] is present more often than hitherto appreciated, is easily diagnosed by roentgen examination. It may be mentioned that Brennemann and his associates,[6] Gittins [3] and others who have reported cases of laryngotracheobronchitis stressed the urgent necessity for rest, and they advised against the use of any measures which would disturb the infant's rest unnecessarily. Roentgen examination, removal of blood for culture, intravenous medication and other procedures are to be carried out only with a minimum of disturbance to an already tired, and at times exhausted, infant.

*Bronchoscopic Picture.*—Bronchoscopic examination according to the writings of Brennemann and his associates,[6] with whom C. Jackson,[2] T. R. Gittins,[3] Lyman Richards,[4] C. L. Jackson [25] and others have expressed agreement, reveals the characteristic

changes throughout the entire lower respiratory tract. These changes consist in intense inflammation of the mucosal lining, with . . . resulting obstruction of the airway in the larynx and in the smaller bronchi. Associated with this is the formation of large quantities of thick, tenacious secretions, equally distributed throughout the tracheobronchial tree. These secretions add to the obstructive symptoms, frequently becoming dry, coagulated and crustlike and adhering to the mucosa. They obstruct the laryngeal airway or even the lumens of the bronchi.

When one depresses the tongue with the laryngoscope, the pharynx frequently shows little change except for a moderate degree of inflammation and the presence of a considerable amount of mucopurulent secretion. Occasionally, however, there is a marked supraglottic obstruction caused by an edematous thickening of the epiglottis, of the aryepiglottic folds and of the false vocal cords. It is this boggy inflammatory edema that would make intubation futile should operative intervention become necessary, because the obstruction would be above the tube.

Generally the milder changes occurring in these structures give no clue to the intense inflammatory process below the cords. Even the cords themselves frequently remain unchanged except for slight redness and thickening and loss of their sharp phonating edges. One striking feature, however, is the almost complete lack of motion of the larynx on respiration and on phonation. The soft subglottic tissues bulge from the phonating edges of the cords to meet in the midline, forcing the cords well apart and thus preventing any motion on phonation.

The mucosa immediately below the cords is changed markedly in color to deep red and has a velvety appearance. Only a small posterior chink allows air to pass. If the anterior portions are not obstructed by the bulging subglottic tissue itself, obstruction is completed by dry yellow crusts or by the tenacious mucopurulent secretion just described. It is this area immediately below the vocal cords which at an early period produces the principal obstruction to the airway.

A small bronchoscope can be insinuated through the posterior chink after suction has been used to aspirate the obstructing exudate lying on the larynx. The bronchoscope is immediately filled with secretion which has accumulated in the trachea. After this has been aspirated with a strong suction pump, the tracheal mucosa is found to be smooth, red and velvety. The lumens of all the bronchi are markedly diminished in size, and the sharp appearance of the bronchial divisions is lost. At this stage the secretion can still be aspirated easily, and

the airways can be adequately kept open if one removes the mucopurulent material either through the bronchoscope or, if a tracheotomy has been done, with a catheter.

Occasionally in patients who have been tracheotomized aspiration through a catheter is not sufficient to relieve the obstruction, owing to the formation of thick, gummy, ropy exudate and of crusts. It may then be necessary to insert a bronchoscope, either through the mouth or through the tracheotomy opening, in order to expose the obstructed bronchus and to remove the crusts with a forceps.

There is an almost terminal stage, however, when the temperature rises steadily, the dyspnea increases and the child gradually becomes more cyanotic or ashen gray. . . . Both phases of respiration are markedly shortened. Aspiration is futile. . . . Because these findings are also present when plaques of exudate firmly adhere to the mucosa and partially obstruct the trachea or both main bronchi, a bronchoscope is used on these patients in an effort to remove obstructing secretions with a forceps.

Terminally, instead of the usual velvety appearance of the mucosa, one finds the lumen free of secretion and exudate and the tracheobronchial tree lined with a dry, glazed and gray surface. It is thick enough to cause narrowing of the lumens of the main bronchi and complete obstruction of the smaller bronchi and bronchioles.

### DIFFERENTIAL DIAGNOSIS

Lederer [32] mentioned the following conditions to be considered in making a differential diagnosis: (1) croup, (2) laryngeal diphtheria, (3) whooping cough, (4) laryngeal edema, (5) papilloma laryngis, (6) micrognathia, (7) macroglossia, (8) foreign bodies in the pharynx and larynx, (9) vegetative laryngotracheitis, (10) simple acute catarrhal laryngitis with symptoms of stenosis, (11) laryngismus stridulus, (12) congenital laryngeal anomalies, such as membrane or web, (13) atelectasis, (14) cerebral hemorrhage, (15) congenital heart disease, (16) other causes of stenosis, such as external pressure of the thyroid, thymus, large mediastinal glands, retropharyngeal, peritonsillar or cervical abscess, (17) pneumonia and (18) bronchial asthma.

It must be added at once that one should be mindful of the dictum of Gittins [3b]: "The diagnosis of serious dyspnea is the important thing, regardless of the cause. If necessary, the diagnosis can be reached after the relief of the obstructive dyspnea." Otherwise, as Myerson [16] specifically mentioned in regard to case 5 of his series, the diagnosis may become a misleading issue. He reported the fact that a 1 year old boy was admitted to the hospital with a croupy cough, increasing dyspnea of two weeks' duration and a chief complaint of severe inspiratory stridor. Bronchoscopic examination revealed edema and exudate on the walls of the trachea and bronchi and narrowing of their lumens. No

32. Lederer, F. L.: Diseases of the Ear, Nose and Throat, Philadelphia, F. A. Davis Company, 1938, p. 592.

foreign body was found. The bronchoscopic examination was followed by severe subglottic edema and reddening of the entire bronchial tree. Tracheotomy was done and was followed by death. Autopsy revealed diffuse bilateral mucofibrinous bronchitis with atelectasis of the upper lobes of both lungs. Myerson commented that a short chain streptococcus caused the tracheobronchitis with sudden intense dyspnea. The consideration of a foreign body was definitely misleading and procrastinating in this case.

### COMPLICATIONS

Complications of acute laryngotracheobronchitis are: (1) endocarditis, (2) myocarditis and acute myocardial degeneration, (3) pericarditis, (4) toxic degeneration of the liver, kidneys and spleen, (5) pulmonary infarct, (6) laryngeal perichondritis and abscess, (7) bronchopneumonia, (C. L. Jackson [2] stressed the importance of not confusing the atelectasis mentioned by some investigators with bronchopneumonia), (8) abscess of the lung, (9) pneumopericardium and (10) pneumomediastinum.

### CAUSES OF DEATH

The mortality may be traced to (1) exhaustion, (2) cardiac or respiratory failure, or both, (3) toxemia, (4) bronchopneumonia, or (5) atelectasis and emphysema. Pneumothorax may be a contributing factor.

### PROGNOSIS

Brennemann and his associates [6] stated the belief that with the best of modern therapy the mortality can be reduced to 25 per cent. C. Jackson [2] expressed the opinion that the mortality ranges from 25 per cent in years when the attacks are mild to 70 per cent in years when they are severe.

### TREATMENT

Before the details of treatment are considered, certain basic principles will bear repetition:

Instrumental intervention alone will give relief for a short while, at most, about twelve hours.

It is imperative that specially trained nurses be in charge and that they exercise unremitting and meticulous vigilance at all times.

Competent residents must be on hand.

A pediatrician must be available.

A bronchoscopist must be accessible.

The patient must be hospitalized.

The hospital should be equipped with a complete bronchoscopic unit.

The hospital should have ready for use several tracheotomy sets.

A room should be provided for the patient in which the proper degree of moisture is maintained in and out of an oxygen tent.

A strong suction pump must be kept in this room.

Sufficient apparatus for suction must be available, such as soft rubber catheters which can be passed through the tracheal cannula.

Teamwork is at all times paramount.

Gittins [3a] advised the early administration of diphtheria antitoxin in all cases, its action as a foreign protein proving beneficial. He stated that, inasmuch as the seriousness of the condition varied in inverse proportion to the age of the patient, one might attempt to deal with mild obstructive symptoms in an older infant by such simple measures as steam inhalations, the use of an oxygen tent and high intake of fluids. Most authors have conceded that intubation may suffice with milder conditions, but Gittins [3b] stated: "Intubation is a serious impediment to the proper treatment of the tracheobronchitis which is of most importance after cannulation. These infections are usually of a descending type."

Howard [23] and Baum [5] showed partiality to intubation. Howard [23] based his opinions on his statistical studies and on other reported cases. He noted the high mortality in cases in which tracheotomy is done early, for acute manifestations, whereas, if such symptoms have subsided, the procedure is far more likely to be successful. In his opinion intubation is the procedure of choice in the treatment of laryngeal obstruction in the acute phase.

Howard [23] summarized his paper with the statement:

> From the data thus collected and from a study of reported cases, intubation seems to be the procedure of choice in the management of the acute stage of both diphtheritic and nondiphtheritic laryngeal obstruction. Tracheotomy performed during the acute stage of inflammation is apt to result fatally, whereas, when done on specific indication after the acute stage is passed, it is almost uniformly successful.

*Intubation.*—The technic of intubation was accurately described by Eschenbrenner [30] as follows:

> Intubation is just like many other surgical procedures. For perfection, one needs some skill and considerable practice. In Isolation Hospital we had a nurse hold the patient upright in the lap and another nurse held the child's head. The important thing, we felt, was to have the head and body in a straight line with the chin out slightly. The mouth is held open with a mouth gag, perferably the Whitehead type. With one index finger the space between the two arytenoids and the epiglottis is located. The tip of the intubation tube is inserted in this space, loosened from its carrier, and pushed down with the index finger, to be covered over with the epiglottis.
>
> Extubation may be done by several different methods. We first attempt to remove the tube by bobbing. The patient, wrapped in a mummy sheet, is held

on a table with its head over the edge, face down, and pressure is exerted on the trachea, milking upward as the head is flexed, and the tube will fall on the floor. This was successful in the majority of cases. The other methods consist in removing the tube with instruments, either directed by touch, using the extubator, or under direct vision through the laryngoscope. The latter two methods are more difficult.

Contraindications to intubation, especially for a prolonged period, i. e., more than several days, are the facts that:

1. Swallowing is at times painful with an intubation tube in place.

2. An intubation tube at times makes pressure necrosis of the posterior tracheal wall.

3. There are many cases on record of laryngeal stricture, or stenosis, following the injudicious use of the intubation tube.

Gittins [3b] condemned the use of the intubation tube because, if the tube remained in the larynx more than three or four days, there was apt to result some damage to the larynx. Howard [23] refuted the statement of Gittins, some of his 34 intubated patients having worn a tube for fourteen days. Baum [5] noted no difficulty in his patients who had intubation tubes left in place for twenty-one days.

Kully [20] said:

An intubation tube, even though it may give quick relief, may come out at any time, and thus a new emergency is created, possibly more urgent than that previously encountered. There is no such danger associated with a tracheotomy tube. A diseased larynx should be put at rest. This cannot be accomplished with an intubation tube which constantly irritates an inflamed mucosa and too frequently results in ulceration with subsequent scarring. Especially is this the case when the intubation has to be repeatedly frequently. Stenosis of the larynx will never follow as a direct result of a tracheotomy properly performed. When the obstruction is due to the formation of membrane the advancing intubation tube may readily force the membrane into the trachea and cause an obstruction which may present a serious problem and possibly death. An inexperienced operator might form a false passage with the intubation tube; two patients were seen in whom the tube had been passed in front of the epiglottis and was found lying under the skin when tracheotomy was resorted to. The intubation tube is not of great value when the obstructive process has extended into the trachea. In such cases a tracheal opening affords a most satisfactory method of removing membrane and secretions from the trachea by suction.

*Suction.*—Tolle [8] advised direct laryngoscopic suction. He indicated that he had found it an admirable procedure for patients with diphtheria and that for the majority of them only one treatment was necessary. In the 22 cases of acute laryngotracheobronchitis reported by him, the treatment was suction alone in 11 cases, suction and intubation in 9 cases and suction, intubation and tracheotomy in 2 cases.

Tolle painted the larynx at each exposure with mercurochrome. He found that suction reduced the necessity for intubation from 41 to 19.8

per cent. He expressed the opinion that suction as he employed it reduced the danger of blocking of the bronchial tubes and of bronchopneumonia.

In discussing the repeated use of suction through the laryngoscope or bronchoscope, Kully [20] stated the belief that this procedure has little place in the treatment of laryngeal obstruction in children. Kully said:

> Obviously aspiration cannot relieve obstruction resulting from edema of the subglottic space, the most common pathologic condition in children with obstructive dyspnea regardless of the etiologic factor. Any increased respiratory effort on the part of a patient suffering from marked obstructive dyspnea may precipitate laryngeal spasm with complete obstruction. This may be brought on by severe exhaustion associated with gagging during laryngeal examination.

It must be added that this is contrary to the experience of the workers at the Willard Parker Hospital, from which Neffson and Wishik [7] reported their cases.

*Tracheotomy.*—Gittins,[3b] Richards,[4] J. Brennemann and his associates,[6] Kully,[20] Tucker,[13] Johnson,[19] Thenebe [18] and Phelps,[17] among other authorities, stated that they favored tracheotomy as the instrumental procedure for the relief of obstructive dyspnea. Eschenbrenner,[30] in analyzing all of the cases of his series that required relief of the obstruction by intubation, by tracheotomy or by both—a total of 406 cases—found that 44 patients, or 10.8 per cent, had such acute obstruction that they required immediate tracheotomy. Although in all of his cases the condition was diphtheritic, it is pertinent to quote his comment:

> Of the remaining 362 cases on whom intubation was first tried, 204, or 50.2 per cent of the cases, could get along without the intubation tube after it had been left in for a total of less than six days. We felt, therefore, that those cases that require mechanical relief with the intubation tube for a period longer than a total of five days should have an elective tracheotomy because those cases will probably need mechanical relief much longer. From examination of the larynges with the laryngoscope it was found that those cases that need mechanical relief longer than a total of five days usually have secondary infection of the larynx with other organisms than the diphtheria bacillus. These secondary invading organisms, such as the streptococcus, staphylococcus and pneumococcus, tend to cause more scar tissue formation than the diphtheria bacillus, resulting in a cicatrical stenosis of the larynx. This is particularly true when there is a chronic irritation associated with the infection, such as that of an intubation tube in the larynx. Clinically the secondary infection was evidenced by marked redness, edema and induration of the structures in the larynx.

He, as well as the previously mentioned writers, favored treatment by elective tracheotomy in all cases in which it is possible.

Richards [1] expressed the belief that in cases in which the obstruction is of a milder nature intubation serves as a therapeutic measure. He insisted, however, that in those cases in which there has been definite involvement of the lower airways, tracheotomy is the procedure of choice.

| Author | Series | Number of Cases | Age of Patient, Years | Incidence According to Sex of Patients | Number Recovering or Dying with Given Form of Instrumental Relief: Intubation Alone — Recovered | Intubation Alone — Died | Intubation and Tracheotomy — Recovered | Intubation and Tracheotomy — Died | Tracheotomy Alone — Recovered | Tracheotomy Alone — Died | Bronchoscopic Treatment and Suction After Intubation | Bronchoscopic Removal of Plugs and Foreign Bodies After Tracheotomy | Total Mortality, % | Total Combined Mortality, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Howard | Nondiphtheritic | .. | Under 2 | M 17<br>F 3 | 2<br>0 | 4<br>2 | 8<br>0 | 1<br>0 | 0<br>0 | 2<br>1 | ..... | ..... | ..... | ..... |
| | | | 2-5 | M 7<br>F 3 | 2<br>0 | 3<br>1 | 0<br>1 | 2<br>1 | 0<br>0 | 0<br>0 | ..... | ..... | ..... | ..... |
| | | | 5-15 | M 4<br>F 0 | 2<br>0 | 1<br>0 | 1<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | ..... | ..... | ..... | ..... |
| | Total | 34 | ..... | ..... | 6 | 11 | 10 | 4 | 0 | 3 | ..... | ..... | .. 53 | ..... |
| | Diphtheritic | .. | Under 2 | M 2<br>F 5 | 1<br>2 | 1<br>1 | 0<br>0 | 0<br>1 | 0<br>0 | 0<br>1 | ..... | ..... | ..... | ..... |
| | | | 2-5 | M 7<br>F 12 | 5<br>7 | 0<br>3 | 0<br>1 | 1<br>1 | 0<br>0 | 1<br>0 | ..... | ..... | ..... | ..... |
| | | | 5-15 | M 0<br>F 3 | 0<br>2 | 0<br>1 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | ..... | ..... | ..... | ..... |
| | Total | 29 | ..... | ..... | 17<br>7 | 6<br>5 | 1<br>5 | 3<br>5 | 0 | 2 | ..... | ..... | 38 | 46 |
| Neffson and Wishik | Nondiphtheritic | 22 | ..... | M 72%<br>F 28% | Plus suction 38%<br>29 | 12 (29%) | ..... | 50% | 1 | 62.5%<br>4 (80%) | ..... | ..... | ..... | 68<br>43 |
| Richards | ..... | 29 | ..... | ..... | 4 | 1 (20%) | | 1 (100%) | 11 | 12 (51%) | ..... | 1 | 35.5 | ..... |
| Baum | ..... | 24 | ..... | ..... | 6 | 1 | 3 | 1 | 5 | 8 | 1 | 9 | ..... | ..... |
| Kully | Nondiphtheritic | 9 | Under 3 (7) | M 64%<br>F 36% | 2 | | ..... | | 27 | 2 | ..... | ..... | ..... | ..... |
| | Diphtheritic | 22 | Over 3 (24) | ..... | ..... | | ..... | | ..... | | ..... | ..... | 6.4 | ..... |
| Smith | ..... | 43 | ..... | ..... | ..... | | ..... | | 8 | 4 (33%) | ..... | ..... | ..... | ..... |
| Thenebe * | ..... | 51 | Under 2 (20)<br>2-5 (14)<br>5-10 (13)<br>10-20 (3)<br>Over 20(1) | M 38<br>F 13 | 3 | 1 (25%) | 16 | 5 (24%) | 2 | 1 (33%) | ..... | ..... | ..... | 14 |
| | | | | | ..... | | ..... | | ..... | | ..... | ..... | 60 | ..... |
| Eschenbrenner | Diphtheritic | 655<br>406 required mechanical relief | ..... | ..... | ..... | | 69 | 67 (49.2%) | 14 | 30 (68%) | ..... | ..... | 25 | ..... |
| Gittins | ..... | 32 | ..... | ..... | ..... | | ..... | | 8 | 12 (60%) | ..... | ..... | 36 | ..... |
| Evans | ..... | 3 | Under 2 (3) | M 2<br>F 1 | ..... | | ..... | | 3 | | ..... | 1 | ..... | ..... |

* Favors an early tracheotomy.

Phelps [17] recommended the use of tracheotomy as an initial procedure because he frequently had to perform a tracheotomy after intubation.

A. W. Proetz, in 1927, in discussing Tucker's [13] paper, advised that a deliberate tracheotomy be done instead of waiting until the patient is in a critical condition.

All the authors agreed that tracheotomy is imperative in the following cases:

1. Cases in which intubation has failed through improper passage of the tube. (One case was reported in which the tube was passed into the tissues anterior to the epiglottis.)

2. Cases in which the tube becomes plugged too frequently, necessitating frequent removal and trauma to the already inflamed laryngeal structures.

3. Cases in which the tube cannot be removed after a period of two (Howard [23]) to three (Baum [5]) weeks without respiratory difficulty.

4. Cases in which there is laryngeal obstruction above the tube.

Before attempting tracheotomy, one can find much of value and comfort in the article of Richards and Glenn [33] on the histologic reactions of the tracheotomic wound.

Their conclusions are, in part:

1. Simple incisions in the trachea, if not infected, tend to heal with great rapidity.

2. The presence of a tracheal cannula delays the healing of the wound and increases the amount of connective tissue formed about it. So long as there is an adequate opening in the trachea for the cannula and no pressure against the cartilaginous edges, there is very little tendency toward the formation of granulations large enough to cause any appreciable obstruction to the tracheal lumen.

3. Infection about the cannula, occasioned primarily by too close approximation of the wound edges about the cannula, increases the tendency to connective tissue formation.

4. With a large anterior tracheal defect there is little tendency for the superficial tissues to fall in and encroach on the lumen of the trachea.

5. With a tracheal fistula, in the absence of a tube, the wound tends to close rapidly without any impairment of the tracheal lumen.

As a result of their experimental work they devised the crucial incision of the trachea.

Technic: An elective tracheotomy is considered here. It is done in the operating room, under strict aseptic precautions and with complete hemostasis.

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33. Richards, L., and Glenn, F.: The Histopathologic Reactions of the Tracheotomic Wound: An Experimental Study, Arch. Otolaryng. **15**:389-412 (March) 1932.

The shoulders of the patient are made to rest over a sand bag; thus the trachea is raised to a prominent position. The procedure is carried on always with the patient under local—never general—anesthesia

The standard textbooks all suggest the vertical incision. Kully [20] advised a short incision, reaching up from the suprasternal notch for a distance of from 2 to 3 cm. Dr. Welt has been employing, with excellent cosmetic results, a curvilinear horizontal incision, low on the neck, about 1 or 2 cm. above the suprasternal notch.

After the incision through the skin has been made, blunt dissection should be employed; thus the vessels which traverse the operative field may be avoided. If a vessel has to be cut, it is wise, if possible, to use a clamp at each side of the point of severance. All vessels which are bleeding freely should be ligated. Kully [20] suggested that hemostats be placed on the cut edges of the different layers of fascia and the ribbon muscles and that these hemostats be allowed to fall to the side of the neck. Kully stated the belief that this weighted hemostat reduces bleeding and, secondly, affords ample retraction. Most important of all, as each deeper layer of fascia is clamped, the trachea is raised to the surface as the hemostats are dropped over the sides of the neck.

Richards' crucial incision of the trachea, through the third and fourth tracheal rings, followed by trimming of the flaps, as suggested by Mosher, with a punch, gives an ample opening for the tracheal cannula. The advantage of such an opening is appreciated when one considers the ease with which the tracheal cannula can be reinserted when necessary, postoperatively.

Suction is constantly employed.

Most operators advise against suturing the cutaneous incision, as it is potentially an infected wound. A slit square of gauze is slipped under the arms of the tracheal cannula, the cannula is tied about the neck and the patient is returned to his room.

I mention high tracheotomy, i. e., tracheotomy above the cricoid cartilage, only to condemn it. Jackson found high tracheotomy responsible for five sixths of the cases of chronic laryngeal stenosis.

Negus advised that a cylinder of carbon dioxide be on hand in the operating room during tracheotomy and for several hours afterward, for use in preventing any respiratory failure.

*Biopsy.*—It cannot be stressed too strongly that the tissues removed from the anterior tracheal wall should be sent to the laboratory for examination. It is only by biopsy that a positive diagnosis can be made, if at all.

*Postoperative Care.*—There is no operation that gives the surgeon greater satisfaction than a successfully performed tracheotomy. Nevertheless, the fact that the operation has enabled an infant who was frantic with struggling for air to breathe with comparative ease and frequently to go to sleep comfortably on the operating table is no reason that one should be put off one's guard and should relax the constant vigilance so vitally urgent in these cases.

The infant should be returned to its room. The temperature of this room should be about 75 F. The moisture present in the room should be maintained. Steam inhalation must be constantly kept up.

Giving water by mouth is better than forcing fluids by clysis or by the intravenous route. If intravenous medication is resorted to, there should be constant supervision, so that the flow of fluid into the blood stream does not take place too rapidly and thus overburden an already strained heart. Lynch [11] stressed the use of alkaline diuretic fluids. More recently many investigators have stressed the use of sodium bicarbonate, administered both by mouth and by enema. Jackson [25] and Coates laid great stress on the use of sodium bicarbonate. Neffson and Wishik [7] suggested the use of whisky. Medication by mouth is questionable. Ipecac, ammonium chloride and other fluidifying expectorants have their advocates. All investigators attempt by every method possible to keep the tracheobronchial secretions fluid, so that they may be easily aspirated by suction through the tracheal cannula.

Gittins,[3] in 1921, started to use epinephrine, at least every half-hour, aspirating the secretions frequently. Neffson and Wishik [7] instilled several drops of a 5 per cent solution of sodium bicarbonate into the trachea every ten to fifteen minutes at first and aspirated the fluids from the trachea through the tracheal cannula by means of a soft rubber cannula. Medicaments such as the mild protein silver and mercurial solutions have also been instilled into the nose and the tracheal cannula. Cassidy [28] reported favorable results from the intratracheal administration of a saline solution of ephedrine (1:1,000) to which a few drops of glycerin was added. In those cases in which Staphylococcus is the causative agent, Evans [28a] advised that staphylococcus bacteriophage be instilled into the trachea, about 5 cc. at a time, at frequent intervals, to be followed by immediate suction.

Specially trained nurses are necessary in these cases. Richards [1] warned that one must be on constant guard against tracheal occlusion, since within a few moments the following events may take place: The child's restlessness increases. The respiratory rate rises to 60. There is a great increase in the audibility of the respiration. There is rapid development of marked substernal retraction and a peculiar change in the general condition, making immediate bronchoscopic treatment the only adequate procedure. Richards added that when in such a case an infant dies and autopsy is performed there is revealed an asphyxial membrane or dry, tenacious masses of fibrinous secretion occluding the larger air passage.

> While bronchoscopic removal of these obstructing masses might in no way have influenced the outcome . . . nor had any beneficial effect on the concomitant mucosal edema, one cannot but feel that in any patient in whom clinical signs suggest obstruction of the airways, regardless of the seriousness of the clinical picture, at least one bronchoscopic examination is warranted as the only means of determining the possible existence of obstructive masses and of removing them.

if present. To regard such patients as "too sick" to tolerate the procedure may at times be to forego the one opportunity of saving the patient's life.

In discussing Berry's [14] paper, Jackson cited Clerf's [12] case. He said:

On one of our cases, an infant, Dr. Clerf did seventeen bronchoscopies for the removal of crusts that were obstructing both lungs at the bifurcation. The crustings after a time ceased to reform. The persistent crustings, however, created a mechanical obstruction in the tracheobronchial airway that threatened asphyxia seventeen times. The patient recovered but would have died of suffocation if these crusts had not been removed. In these cases when breath sounds diminish over both lungs, bronchoscopy should be done to determine whether or not crusts at the bifurcation are obstructing both main bronchi.

In discussing this same paper, Richards [1] cited a case in which there was mild obstruction and in which he succeeded in relieving the difficulty by intubation.

TABLE 2.—*Intubation and Tracheotomy in Cases of Diphtheritic Laryngotrachcobronchitis (After Howard [23])*

| Method of Treatment | Total Number of Cases | Cases in Which Intubation Tube Was Used for: | | | Cases in Which Tracheotomy Tube Was Used for: | | |
|---|---|---|---|---|---|---|---|
| | | Less Than 4 Days | 5 to 9 Days | 9 to 14 Days | 10 to 30 Days | 30 to 50 Days | Over 50 Days |
| Intubation | 6 | 4 | 2 | — | — | — | — |
| Tracheotomy | 0 | — | — | — | — | — | — |
| Both | 10 | 1 | 4 | 5 | 6 | 2 | 2 |

Baum [5] noted that in 10 of his cases it was necessary to remove plugs from the lower respiratory tract by means of a bronchoscope. Nine bronchoscopic treatments were done for patients with tracheal cannulas, and only one for a patient breathing through an intubation tube. Baum granted that, although he previously performed tracheotomy first, he had become more inclined to try intubation first. He stated the belief that the air coming into the trachea directly through a cannula tends to dry the trachea and the bronchi unduly and to cause the formation of crusts. This result, according to Baum, does not occur when the air, partially moistened in the nose, is breathed through an intubation tube. According to the pathologic investigations of Richards [1] and of Brennemann and his associates,[6] the plugs and crusts found in cases of severe acute laryngotracheobronchitis are primary products of the pathologic process. They are found at autopsy in cases in which there has been no instrumental intervention. They are a measure of the severity of the obstructive process as well as of its extent.

Decannulation: Table 2 (adapted from a report by Howard [23]) presents data on cases of nondiphtheritic laryngotracheobronchitis.

C. Jackson advised decannulation on about the fourteenth day.

REPORT OF A CASE

P. B., a white girl aged 2 years was admitted to Prospect Heights Hospital on Feb. 23, 1939. The chief complaints were severe respiratory distress, a cough irritability and drowsiness. She had been perfectly well until one week before admission, when she was awakened from sleep at about 10 p. m. by severe respiratory difficulty. She could not catch her breath and became definitely dyspneic and cyanotic. With inhalation of tincture of benzoin steam and expectorant medication, this attack subsided. For several days prior to admission the infant had a constant cough. There was a watery nasal discharge.

During the night before admission the infant had severe difficulty in breathing. This condition was intermittent, the infant becoming blue with each attack of dyspnea and coughing constantly.

After the use of castor oil and a soapsuds enema there was slight improvement, but the infant still had difficulty in breathing. She was very tired but could not fall asleep because of the strenuous effort necessary to breathe.

*Physical Examination.*—Examination at 2 p. m. revealed a well nourished white girl 2 years of age, who was acutely ill. There was a malar flush. The skin was a dusky grayish pink. The lips and finger tips were cyanotic. The infant appeared toxic and quite exhausted.

The lips were dry. The pharynx was red. There were discrete white spots in the follicles of the right tonsil. There was a seropurulent discharge in the throat. A serous watery nasal discharge was present at the anterior nares. The infant would attempt to hold her head erect during the examination, but the head would roll toward either shoulder for a few moments, only to be forced up by the strenuous muscular efforts necessary to breathe.

Respiration was labored, with marked inspiratory difficulty, accompanied by marked suprasternal retraction and slight supraclavicular and intercostal retraction. At the end of each inspiration was a harsh, phonic, nonexpectorant cough.

The infant was very drowsy but could be easily aroused and was then mentally alert.

Large rhonchi were heard in the chest, but the examination of the chest otherwise gave essentially negative results. A diagnosis of acute laryngotracheobronchitis was made. Material for culture was taken from the nose and the throat.

*Preoperative Treatment and Course.*—Intramuscular injections of azosulfamide[34] were instituted.

At 4 p. m. the respiratory distress became more marked.

Inspiration: There was a two stage inspiratory effort. The first stage consisted of a short inspiration preceded by a forward and upward fixation of the shoulders. This was followed by a most strenuous inspiratory effort, accompanied by marked suprasternal, supraclavicular and intercostal retraction. Each inspiratory effort was accompanied by substernal retraction, with an outward thrust of the abdominal muscles.

Expiration: There was evidence of expiration of air against an obstruction. There was a ballooning of the suprasternal notch and an inward thrust of the abdominal muscles with each expiration. The pulse was full and rapid. The infant appeared tired and very drowsy. She would seem to try to sleep, with her head resting on either shoulder, but the need for air would constantly awaken her

34. Azosulfamide is disodium 4-sulfamidophenyl-2′azo-7′-acetylamin-1′-hydroxynaphthalene-3′,6′-disulfonic acid. This substance has been known as prontosil soluble, as prontosil and as neoprontosil.

from momentary sleep. The infant could not rest unless she was held up or was supported by pillows in a sitting position. The skin was a grayish dusky pink. The infant was bathed in perspiration.

Direct Laryngoscopic Examination: The epiglottis was red. The arytenoids were edematous and red and interfered with the motility of the vocal cords. There was a profuse mucoid discharge.

Preoperative Condition: At 4:30 p. m. the infant's condition became rapidly and progressively worse. During one coughing spell she became extremely restless and darkly cyanotic and actually struggled for air.

An immediate tracheotomy was advised.

An oxygen tank was kept immediately at hand, because each succeeding paroxysm of coughing made the infant deeply cyanotic. By the time she reached the operating room, she was so exhausted that she could offer little resistance to being prepared for operation.

*Tracheotomy.*—At 5:40 p. m. an elective tracheotomy was begun. It was completed at 6:15.

Some whisky in sweetened solution was given to the infant before operation.

Tincture of merthiolate was employed for antisepsis of the skin of the neck and the upper part of the thorax.

Position of the Head: The infant was "mummified" in a sheet and held on the operating table by a nurse. A sandbag was placed under the neck, thus extending the head. The head was held in position by an attendant, who made sure that the chin was directly in midline and pointing up.

Anesthesia: Local infiltration, low and across the neck was used. The anesthetic was 1 per cent procaine hydrochloride with 10 drops of solution of epinephrine hydrochloride (1:1,000) to the ounce.

Incision of the Skin: An incision was made low in the neck, about ½ inch (1.27 cm.) above the sternoclavicular joints, transversely (as for thyroidectomy) and in line with the natural fold of the skin.

Further Procedure: The tissues in the midline of Jackson's triangle were separated by blunt dissection, done with blunt scissors and scalpel handle. Whenever possible, as soon as a vessel was exposed, if it was in the operative field, it was clamped and then cut. The hemostats were permitted to hang over the side of the neck. The ribbon muscles were separated laterally, and the trachea was exposed. A small narrow-bladed retractor was placed at the lower angle of the wound as a precaution against the ballooning of the pleura into the tracheal wound during expiration.

The first step preparatory to making an opening into the trachea was locating approximately the third and fourth tracheal rings. The Richards[1] crucial incision was employed. This consists of a transverse incision (made if possible during an inspiratory effort of the patient) between the third and fourth tracheal rings and then a vertical incision, through the approximate parts of the third and fourth tracheal rings, perpendicularly bisecting the horizontal tracheal incision. The four corners were then trimmed with a small punch forceps. An opening into the trachea was thus made, sufficiently large to admit the entrance of a number 3 tracheotomy cannula without undue pressure at the margin of the opening.

Strict hemostasis was employed. As soon as the trachea was entered, suction was employed by the use of a soft rubber catheter in the trachea.

Observations: Immediately when the trachea was opened there was a profuse flow of a purulent exudate mixed with mucoid material. The tracheal mucosa was seen to be thickened and reddish gray.

Sutures: Two silk sutures approximating the edges of the skin were placed. (They later sloughed out.)

A small square of gauze was slit halfway and slipped under the arms of the tracheotomy tube; the tube was held in place by tying the tapes at the side of the neck. After the opening was made into the anterior tracheal wall, the infant became quiet and began to breathe quietly, though rapidly. The skin became pink.

The tissue removed when the corners of the tracheal opening were trimmed was sent to the laboratory for diagnosis.

*Postoperative Course.*—The infant was returned to her room and the following orders were given to the nurse:

1. Maintain the saturation of the air of the room with moisture.

2. Keep up constant inhalation of compound tincture of benzoin steam.

3. Instill 6 drops of a 1:1,000 solution of merthiolate into each nostril and into the tracheal cannula every two hours.

4. Occasionally instill several cubic centimeters of physiologic solution of sodium chloride into the tracheal cannula. Alternate this with several cubic centimeters of 5 per cent solution of sodium bicarbonate. Remove the solutions by aspiration shortly after instillation.

5. Apply suction through the tracheal cannula frequently, at least every ten to fifteen minutes, or oftener if necessary.

6. Force fluids by mouth; add a pinch of sodium bicarbonate to each fluid given.

7. Give 100 cc. of physiologic solution of sodium chloride by clysis.

8. Continue the intramuscular administration of 10 cc. of azosulfamide every four hours.

9. Do not disturb the infant if she is resting or sleeping quietly.

Follow Up Notes: At 6:30 p. m. (Feb. 23, 1939) immediately after tracheotomy, the breathing and color improved. The pulse was rapid but regular. The child vomited thick brownish mucus.

At 9 p. m., the child was resting, breathing without difficulty and occasionally coughing and expectorating seropurulent material through the tracheal cannula. Slight suprasternal and intercostal retraction with inspiration was noted. When the inner tracheal cannula was removed, there was more adequate breathing space, resulting in a marked diminution of the accessory respiratory tug.

At 10 p. m., the child was sleeping soundly.

At 11 p. m., she awoke coughing. She expelled mucopurulent exudate.

At 12 p. m., she was breathing comfortably. There was coughing with expectoration. The infant was toxic.

During the early morning hours (February 24) she slept at intervals. The temperature was rising and she was perspiring freely and was incontinent of urine.

At 5:30 a. m., the infant was drowsy and was perspiring profusely. She did not take fluids well. Her condition became progressively worse. She perspired profusely and was incontinent of urine, losing fluids rapidly. She refused fluids by mouth. On several occasions when she was given water or milk to drink she had a severe attack of coughing. She was gradually becoming more drowsy.

Twenty-four hours after the operation the outer tracheal cannula was removed. It was found to be practically occluded by a gummy exudate, which was removed with difficulty; scraping was necessary to clear the lumen of the cannula. The wound tract was cleansed, and suction of the trachea was easily performed through the wound. The tracheal cannula was reinserted with ease simply by spreading

the edges of the wound and gently directing the cannula into the opening made in the tracheal wall by the Richards crucial incision technic.

After this, new nurses were obtained for the case. They had had special training in the care of tracheotomized patients. The first nurse's note, made on arrival, was: "Infant in considerable distress. Respiration rapid (48) and brassy. Pulse bounding (168). Infant very restless. Respirations appear to be getting more difficult. Infant shows signs of exhaustion."

By frequently changing the inner tracheal cannula, it was kept constantly patent. The suction catheter was passed into the trachea, and thick mucus was aspirated. Fluids were forced by clysis, 100 cc. of a 2 per cent solution of dextrose

Graphic representation of the patient's condition during the first fourteen days in the hospital.

and sodium chloride being used on three occasions. When possible, fluids were given by mouth. Sodium bicarbonate was used both in the fluids administered by mouth and in the soapsuds enema.

Frequent physical examinations of the chest failed to reveal any gross change in physical signs.

The note made by the attendant at 8 p. m. on February 25 was: "Infant alert. Sitting up in bed. Breathing comfortably. Playing with toys."

From this time on the condition of the infant was good except for frequent attacks of coughing and profuse rhinorrhea and perspiration. Her eyes, which appeared hollow and sunken, became brighter.

Occasionally the outer end of the tracheal cannula was obstructed, and the infant became restless.

On February 26, the progress note was: "Infant resting. Appears very tired. Facies slightly sunken. No rales in chest. Heart to left, heart sounds satisfactory, rate rapid. Color of infant improving. Purulent exudate aspirated from nose and from oropharynx. Temperature subsiding."

On February 27, the child was breathing comfortably. She coughed occasionally, with expectoration through the cannula, but she was playful.

On March 2, the entire tracheotomy tube was removed for one hour. The patient coughed, producing a mucopurulent exudate. There was sloughing of the wound with induration of the skin and the subcutaneous tissues. The child's color becoming dusky, the tube was reinserted.

On March 5, the tracheotomy tube was removed. The infant coughed, producing a large amount of clear, stringy, colorless mucoid exudate. She was comfortable and the tube was not replaced, i. e., decannulation took place on the tenth day.

On March 22, the wound was healed, the chest was clear and the patient was discharged as cured.

*Laboratory Work-Up.*—Bacteriologic Findings: Smears of the material from the nose and throat yielded many gram-positive cocci in diplococcic and streptococcic form but nothing suggestive of Bacillus diphtheriae. A culture of the discharge from the nose and from the throat gave a growth of anhemolytic streptococcus and of Staph. aureus.

Anhemolytic streptococcus was found in the exudate from the trachea.

In regard to pneumococcus typing, there was no reaction with any known serum. Inoculation of mice did not produce growth of organisms.

Blood Count: The erythrocyte count was 3,390,000, the hemoglobin content 64 per cent and the leukocyte count 6,200, with neutrophils 58 per cent, eosinophils 2 per cent, small lymphocytes 25 per cent, large lymphocytes 12 per cent and monocytes 3 per cent. There were no basophils.

Urinalysis: The urine showed an occasional trace of albumin.

Biopsy: The tissue removed from the tracheal opening was composed of hyalinized cartilage covered by necrotic mucosa which contained secreting glands. There was a partial denudation of the lining. The diagnosis was necrosis and ulceration of the mucous lining.

*Comment.*—The early postoperative course is reported in some detail. It emphasizes the urgency of:

1. Constant medical vigilance.

2. The attendance of specially trained nurses—nurses acquainted with the constantly changing picture of the tracheotomized infant suffering with acute laryngotracheobronchitis.

3. Frequent suctioning through the tracheal cannula in order to (*a*) keep it patent, (*b*) make sure that there is no obstruction at the inner end of the cannula and (*c*) keep the trachea as clear of exudate as is possible by using soft rubber catheters on the suction tip.

## SUMMARY

Acute laryngotracheobronchitis is a clinical entity found in infants and characterized by obstructive dyspnea requiring instrumental inter-

vention. This should be carried out early, when the diagnosis of progressive obstructive dyspnea is made. A more exact diagnosis can be made, as in the case reported, by examination of gross and microscopic sections of the tissues removed from the anterior tracheal wall.

It seems that in cases in which the dyspnea is mild, intubation is a helpful and curative procedure, particularly in the hands of skilled technicians. In cases in which the dyspnea is more severe, especially in those in which bronchoscopic examination and suction for the removal of plugs or membrane may be necessary, tracheotomy seems to be the more versatile and appropriate measure.

For tracheotomy, a transverse incision of the skin gives a better cosmetic result after the tracheotomy wound heals.

The use of the Richards crucial incision into the trachea is advocated.

Constant vigilance at all times by specially trained nurses is necessary in these cases.

Cooperation between the pediatrician and the laryngologist can reduce mortality figures from ranges of 50 to 100 per cent to 25 per cent or less.

A case is reported. The diagnosis was confirmed after tracheotomy by biopsy of the fragments of the anterior tracheal wall. The patient was cured.

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# PATENCY OF THE EUSTACHIAN TUBE IN RELATION TO PROFOUND HEARING LOSS IN CHILDHOOD

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Recent reports [1] recording the results of irradiation of the eustachian orifice and tube have focused attention on disease of this structure in children in relation to the improvement of their hearing and the presumed effect of such disease in childhood on the development of deafness in adult life. In the Pennsylvania School for the Deaf, at Mt. Airy, there are in residence 540 children. The assigned causes of deafness in these children are: biologic defect, 53 per cent; meningitis, 17 per cent; trauma, 14 per cent; contagious diseases (such as measles, scarlet fever and their sequelae), 15 per cent and incidental causes, 1 per cent.

In a previous report [2] true congenital deafness was shown to be a relatively unusual condition, since an insignificant number of the children in this group had parents who were born deaf. In consequence the term "biologic defect" was substituted to fulfil the requirements of statistical data. This group of 53 per cent represents those children who were actually born deaf or in whom the impairment developed in the first three years of life. It is felt that the biologic defect may render the individual child's auditory apparatus more susceptible to a variety of conditions, such as infections of all kinds and degrees. In addition, mechanical factors and nutritional or endocrine disturbances may play a part. To all of these the normal person in this age group would probably be immune or at least present a higher degree of resistance so far as the auditory mechanism is concerned.

However, if this percental incidence is accepted as a fact, it might be expected that in certain cases the entire auditory mechanism, the

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From the Pennsylvania School for the Deaf and the Otological Research Laboratory of the Abington Memorial Hospital.

1. Crowe, S. J., and Baylor, J. W.: The Prevention of Deafness, J. A. M. A. **112**:585 (Feb. 18) 1939.

2. Hughson, W.; Ciocco, A., and Palmer, C.: Studies of Pupils of the Pennsylvania School for the Deaf: I. Auditory Acuity, Arch. Otolaryng. **29**:403 (March) 1939.

inner and middle ear and the pressure-regulating apparatus, would be involved in the defective development. In the present survey the latter function has been investigated and analyzed in relation to the assigned cause of deafness, the familial relationship, the extent of auditory loss, the pathologic conditions observed and the measured patency of the eustachian tube.

## TECHNIC OF DETERMINING PATENCY

Perlman [3] has reported a method to determine the actual pressure changes required to open the eustachian tubes of normal persons. In the present study his technic has been simplified to a certain extent, the following procedure having been employed:

Instead of a mercury manometer, a water manometer has been used. This permits greater accuracy in measuring pressure, because of the greater amplitude of excursion of the fluid column. For all practical purposes and also from the standpoint of comfort it is felt that 60 cm. of water may be regarded as the maximum pressure that should be used. If any pressure greater than this is required to open the tube, it indicates definite pathologic constriction. Perlman reported that pressures as high as 55 mm. of mercury or 74.25 cm. of water were needed in his normal group. It is thought that the use of such high pressures may be hazardous, as it has been shown experimentally in animals [4] that rupture of the drum may occur after the application of pressures greater than 60 mm. of mercury.

At the time of test the subject is instructed to take a deep breath; a nasal tip connected with the water manometer is then placed firmly in one nostril, the opposite nostril and the mouth are tightly closed, and the breath is forcibly exhaled through the nasal tip. The subject observes the level of water at which the tube opens, and this is further checked by use of the diagnostic tube. Repeated observations are reasonably consistent so long as no infections of the upper respiratory tract intervene. Even moderate congestion of the pharyngeal mucous membrane will cause occlusion of the eustachian tube. No difficulty has been found in testing children from 7 years of age upward. Subjective observation is an advantage, particularly in the testing of children, since it introduces the stimulating factor of competition, which encourages attention and effort. The photographs illustrate the apparatus employed and the method of testing.

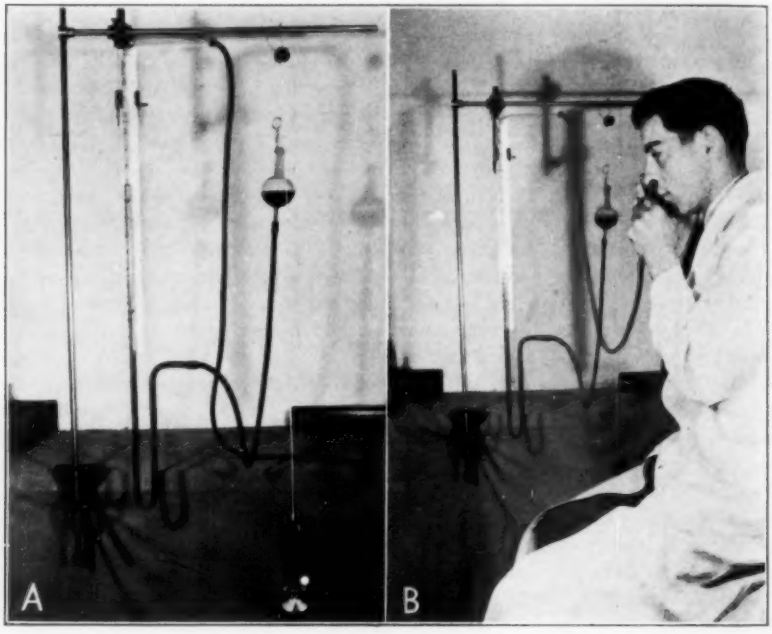
## OBJECT OF THE REPORT

In the following recapitulation of recorded data an attempt has been made to correlate observed loss of hearing, otologic conditions, the stated causal factor, nasopharyngoscopic findings and hereditary factors with patency of the eustachian tube. The detailed and careful analysis has been made entirely by one of us (C. Y. M.). It will be noted that in a certain percentage of the cases the nasopharyngoscope was not passed. The two factors responsible were nasal obstruction, a relatively unimportant finding, and the age of the child examined. Naturally the younger

3. Perlman, H. B.: The Eustachian Tube: Abnormal Patency and Normal Physiologic State, Arch. Otolaryng. **30**:212 (Aug.) 1939.

4. Thompson, E.; Howe, H. A., and Hughson, W.: Middle Ear Pressure and Auditory Acuity, Am. J. Physiol. **110**:312 (Dec.) 1934.

children were less cooperative. The production of anesthesia, either local or general, seemed unwarranted under the circumstances. Whether the nasoscopic examination was made or not, the observed percental incidence of adenoid tissue impinging on the eustachian orifice might well be expected to remain relatively constant for the entire group. Further, it is felt that so far as tonsil and adenoid disease is concerned this group of deafened children is representative of any control group of school children with normal hearing. Indeed, in this group probably more attention is paid to tonsil and adenoid disease than in a corresponding group of children with normal hearing.




*A*, water manometer with scale calibrated in centimeters. The fluid level is adjustable by raising or lowering the reservoir. When pressure is exerted the fluid column is displaced downward. The fluid is colored for convenience in reading. *B*, the manometer in use for testing. The subject notes the level on the scale at which the tube opens, and this is checked by an observer, who uses a diagnostic tube. If there is any question as to the result, the observer's reading is selected for record.

Preconceived ideas in regard to prenatal, neonatal and biologic deafness and even true congenital deafness are readily obtained. In the vast majority of cases the impairment is undoubtedly developmental or neural in origin. A survey of the family history and the contributory factors during intrauterine life fails to reveal any significant influence associated with the impairment of hearing of the individual child.

However, it can reasonably be expected that abnormalities of the middle ear may also be concerned in the auditory difficulty. Crowe has reported mesenchymal rests in the middle ears of children dying of some intercurrent disease after impairment of hearing had been established. Mesenchyme is present in the animal middle ear up to and after birth. Its persistence might well influence aeration of the middle ear cavity and be a factor in obstruction of the eustachian tube and consequent impairment of hearing. However, there is no adequate histologic evidence to support this supposition in such a group as the one under discussion.

The following statistical data are reported more as a matter of record than with any idea of their having particular etiologic or diagnostic significance. It is felt that no single factor should be neglected in the effort to solve the problem of biologic or hereditary deafness. For this reason the results of examinations of the eustachian tubes of a significant number of seriously deafened children are reported for the first time.

## ANALYSIS OF RESULTS

Three hundred and thirty-one children with impaired hearing were tested in the manner described. In the age group 9 to 15 years 105 of a total 167 were shown to have patent eustachian tubes. It was possible to make nasoscopic examination of 117 of these children without the employment of anesthesia. In 8 adenoid tissue was apparent, 3 had anatomic restriction in the size of the orifice and in 1 the orifice could not be seen. One hundred and twenty of these children had normal tympanic membranes; of the others 42 had thickening and retraction of varying degrees, while 5 had chronic suppuration. One hundred and twenty-two did not give a family history of deafness, while 45 did give such a history but not one of deafness which could be considered truly congenital.

Audiometric examination of the children of this group showed: a handicapping impairment, 40 to 50 decibels in the speech frequency range, in 1 child; impairment, 50 to 60 decibels, with speech difficulty in 16; profound loss of hearing, 60 to 75 decibels, and speech difficulty in 14, and no useful hearing or speech, i. e., a loss of 80 to 100 decibels, in 136. In this group 62.2 per cent were shown to have patent eustachian tubes: those of the boys opened at an average pressure of 41.6 cm. of water (high, 60 cm.; low, 23 cm.) and those of the girls at 38.2 cm. of water (high, 47 cm.; low, 21 cm.). In 4 children who were actually observed to have adenoid tissue about the orifice, inflation failed; in 8 with definite adenoid impingement, the tube inflated normally.

A second group, 164 children, aged 15 to 21 years, provided the following data: Nasoscopic examination was successfully carried out on 132 without anesthesia. In 101 the eustachian tubes opened at an average pressure of 40.2 cm. of water, with extremes of 56 and 27 cm.,

in boys and 39.5 cm. of water, with extremes of 48 and 17, in girls. Fourteen had adenoid tissue about the orifice, but in only 7 of this group did the eustachian tubes fail to inflate normally. One hundred and fourteen had normal tympanic membranes; 26 of those whose tubes failed to inflate had thickening of the drum membrane and some retraction. Thirty-eight gave a rather indecisive family history of deafness. One hundred and twenty-five gave no family history of deafness.

In both age groups the assigned causes of deafness remains relatively the same, with a possible increase in acute infections as etiologic factors in the older group.

The loss of hearing in the older group is almost identical with that already described. Three patients showed a handicapping impairment, 11, impairment of hearing and speech difficulty, 13, profound loss of hearing and speech difficulty and 137, no useful hearing.

Audiograms of these children are made at least once a year from the time of their admission to the school, at the age of 6 years, until graduation, at approximately 21 years.

The data for the groups in relation to age and sex, patency of the eustachian tubes, success or failure in passing the nasopharyngoscope, observed pathologic conditions and measured pressures are shown in the accompanying table:

*Correlation of Patency of Eustachian Tube with Other Data on Three Hundred and Thirty-One Deaf Children*

| | Age Group 9 to 15 (Total 167) | | | | Age Group 15 to 21 (Total 164) | | | |
|---|---|---|---|---|---|---|---|---|
| | 106 Boys | | 61 Girls | | 96 Boys | | 68 Girls | |
| Factor Correlated | 66 Patent | 40 Obstructed | 39 Patent | 22 Obstructed | 57 Patent | 39 Obstructed | 44 Patent | 24 Obstructed |
| **Stated cause** | | | | | | | | |
| Congenital | 6 | 5 | 3 | 2 | 7 | 5 | 1 | 2 |
| Hereditary | 1 | .. | 1 | .. | 4 | .. | 1 | .. |
| Biologic | 9 | 4 | 10 | 3 | 16 | 10 | 6 | 9 |
| Infection | 19 | 20 | 17 | 9 | 20 | 12 | 22 | 3 |
| Trauma | 11 | 4 | 3 | 3 | 4 | 4 | 2 | 1 |
| **Family history** | | | | | | | | |
| Deafness | 17 | 8 | 12 | 8 | 12 | 11 | 10 | 5 |
| No deafness | 49 | 32 | 27 | 14 | 44 | 28 | 34 | 19 |
| **Otoscopic observations** | | | | | | | | |
| Normal | 46 | 27 | 33 | 14 | 44 | 24 | 33 | 13 |
| Pathologic | 18 | 12 | 4 | 8 | 12 | 15 | 10 | 11 |
| Perforation | 2 | 1 | 2 | .. | 1 | .. | 1 | .. |
| **Nasoscopic examination** | | | | | | | | |
| Nasopharyngoscope passed | 51 | 24 | 28 | 14 | 48 | 32 | 34 | 18 |
| Nasopharyngoscope not passed | 15 | 16 | 11 | 8 | 9 | 7 | 10 | 6 |
| Adenoids | 7 | 4 | 1 | 0 | 1 | 5 | 6 | 2 |
| **Loss of hearing** | | | | | | | | |
| Group 1 | .. | 1 | .. | .. | .. | 2 | .. | 1 |
| Group 2 | 4 | 6 | 2 | 4 | 5 | 2 | 3 | 1 |
| Group 3 | 7 | 2 | 5 | .. | 3 | 4 | 3 | 3 |
| Group 4 | 55 | 31 | 32 | 18 | 49 | 31 | 38 | 19 |
| **Pressure level, cm. of $H_2O$** | | | | | | | | |
| Average | 41.6 | | 38.2 | | 40.2 | | 39.5 | |
| High | 60 | | 47 | | 56 | | 48 | |
| Low | 23 | | 21 | | 27 | | 17 | |

SUMMARY

Three hundred and thirty-one children with loss of hearing which required their being educated in the Pennsylvania School for the Deaf were examined to determine whether or not the eustachian tubes were patent within relatively normal limits. Using a simple method of measured autoinflation and considering 60 cm. of water a pressure requirement beyond which function of the eustachian tube could no longer be considered normal, we have made an attempt to correlate the results of our examinations with the other factors involved. The children examined have been divided into two age groups, 9 to 15 and 15 to 21. Naturally nasopharyngoscopic examination was carried out more successfully in the older groups. In the children so examined the presence of adenoid tissue near the eustachian orifice was an unusual finding and when present was apparently not an important factor in relation to tubal patency.

No apparent relationship exists between biologic deafness with profound loss of hearing and inflatability of the middle ear. Even thickening and retraction of the drum membrane were not particularly frequent in the patients whose tubes failed to inflate.

The relative numbers in the two groups of those whose tubes inflated and those whose tubes failed to do so are approximately the same in relation to both age and sex.

Since the great majority of the children, as shown by audiometric measurement, do not have useful hearing, it cannot be said that in this group either patency or obstruction of the eustachian tube is a factor of real importance.

Routine demonstration of the patency of the eustachian tube by the method described is a relatively simple procedure, and if repeated at stated intervals on children with normal hearing or only slight impairment it might well serve as a warning of impending difficulty and certainly as an index of the effectiveness of therapy.

Such a study of a considerable number of children with normal hearing might well clarify various uncertainties now existing relative to the actual role of the eustachian tube in the development of chronic progressive deafness.

# PARANASAL SINUSITIS IN RELATION TO SYSTEMIC DISEASE, WITH SPECIAL REFERENCE TO DIAGNOSTIC LAVAGE

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The significance of paranasal sinusitis as a local disease and its importance as a focus of infection in relation to a variety of systemic diseases are generally recognized. The pertinent problem at present is to discover the sinusitis when it exists, and this involves an evaluation of the evidences of infection as disclosed by the methods of investigation employed. Recognition of sinusitis is simple when there are local manifestations, but it is not generally understood that an infection of the paranasal sinuses may exist in the absence of local manifestations. Watson-Williams [1] has written of such sinusitis as "latent or occult infections"; Harper [2] has called this type of sinusitis "hidden infection," and Sohval and Som [3] have used the term "masked sinusitis" in reporting cases of obscure fever. It seems best to consider these infections of the paranasal sinuses as silent so far as symptoms, local manifestations and apparent relation to systemic diseases are concerned. Thus, the paranasal sinuses must be investigated regularly as a possible source for headache or fever, especially when following infections of the upper respiratory tract, or for a focus of infection, even though no symptoms or physical evidences of sinusitis are presented.

A complete investigation for the purpose of discovering an infection of the sinuses entails a direct examination of the upper respiratory tract, transillumination and roentgenologic study of the sinuses and diagnostic lavage of the maxillary antrums and the sphenoid sinuses. The comparative value and accuracy of these diagnostic methods have been the subject of much argumentative discourse among rhinologists in recent years. Unfortunately the conclusions and opinions of various authors have differed greatly in respect to some of these points, par-

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From the Laryngologic Service of Dr. Rudolph Kramer and the laboratories of the Mount Sinai Hospital.

1. Watson-Williams, P.: Chronic Nasal Sinusitis, ed. 2, London, John Wright & Sons, Ltd., 1933.

2. Harper, J.: Importance of Nasal Sinusitis in General Practice, Glasgow M. J. **8**:1 (July) 1936.

3. Sohval, A. R., and Som, M. L.: Masked Sinusitis as a Cause of Obscure Fever, Arch. Otolaryng. **25**:37 (Jan.) 1937.

ticularly the need for irrigation of the sinuses. These different views have clouded the problem of discovering foci of infection in the paranasal sinuses. Because of the importance of this problem I wish to appraise once again some of the diagnostic criteria of sinusitis, especially with regard to the use of diagnostic lavage, and also to point out certain investigations necessary in order that one may interpret properly the findings obtained by the various diagnostic methods. In this way it may be possible to contribute to the clarification and better understanding of paranasal sinusitis as a source, or focus, of infection.

## DIAGNOSTIC CRITERIA

Intranasal conditions observed on direct examination cannot be regarded as definitive evidence of the existence or absence of an infection of the sinuses. It is certainly more reliable to consider the condition of the mucous membrane of the turbinates and the presence of polypoid alterations or secretion in the various recesses merely as suggestive evidence which requires further diagnostic investigation. The maxillary antrums and the sphenoid and frontal sinuses can be further examined by transillumination, roentgenologic studies and lavage. Roentgenologic examination is the only method commonly used for detailed study of the ethmoid cells. Watson-Williams has obtained information concerning the posterior ethmoid cells by "suction-exploration." In cases in which the ethmoid labyrinth must be regarded as a possible focus of infection because of certain suggestive conditions, it may be necessary to operate in order to determine the presence of a purulent infection. Such an exploratory procedure should be entertained, of course, only when the systemic condition is serious and it is imperative to rid the body of infected foci. Exploratory laparotomies are performed with similar purposes in view.

It is generally admitted that transillumination is not a completely reliable diagnostic method for use in the search for infections of the sinuses.[4] Cloudiness of a maxillary antrum on transillumination is a suggestive sign which may or may not indicate an active infection. Infection of an antrum may exist even though the sinus on transillumination is clear. This was demonstrated in 400 cases in which irrigation of the maxillary antrum was done in my private practice. In 175 cases the antrum was cloudy on transillumination and yielded positive washings; in 97 the antrum was cloudy and washings were clear; in 92 the antrum and washings were clear, and in 36 the antrum was clear but the washings were positive. Positive washings comprised either a collection of secretion or flakes obtained from the sinus.

4. Gafafer, W.: Transillumination and Roentgenography of the Maxillary Sinuses: A Review, Arch. Otolaryng. **14**:737 (Dec.) 1931.

In children especially I have seen antrums which appeared clear on transillumination yet yielded a large amount of mucopus on lavage.

There seems to be greater need of roentgenologic examination in cases in which the sinuses are suspected of harboring a focus of infection than in cases of sinusitis unassociated with systemic ailments, for in a case of the former type the condition of the mucous membrane of the sinuses may be significant. In uncomplicated cases of sinusitis the frequent use of lavage of the sinuses in addition to the direct methods of examination fulfils most of the diagnostic needs. In cases of systemic involvement in which the status of the sinuses is not evident and in uncomplicated cases of sinusitis in which the condition does not react favorably to treatment or requires operative intervention it becomes necessary, as a rule, to resort to roentgenologic examination.

It must be realized also that not infrequently roentgenograms fail to represent the true condition of the sinuses. It is well recognized that a cloudy or hazy sinus may not contain any secretion. It is much more important, however, to be aware that purulent secretion may exist in a sinus which appears clear on the roentgenogram. Although roentgenologic examinations have been requested comparatively infrequenty in the investigation of the sinuses of private patients, I have seen in the past two years in persons with systemic complaints at least three maxillary antrums and three sphenoid sinuses (in 6 patients) which appeared entirely clear in roentgenograms and yet yielded purulent secretion on lavage. Routine comparison between roentgenograms and the results of lavage of the sinuses undoubtedly would have revealed many such discrepancies.

A great difference of opinion exists among rhinologists concerning the exact indication for lavage of the maxillary antrums and sphenoid sinuses in investigations of these sinuses. Most authors believe that this procedure should be used especially as a means to "prove" the existence of a suspected infection. In other words, further investigation by lavage is deemed warranted when there are manifestations of disease, particularly those revealed by roentgenograms. Unfortunately this point of view will lead one to miss important infections of the sinuses. In considering the sinuses as a potential focus of infection, a negative roentgenogram cannot be regarded as incontrovertible evidence of the absence of infection, although it is appreciated that positive roentgenographic observations may prove to be significant. The mucous membrane of an antrum may be diseased without any manifest hyperplasia or swelling, and there may be secretion containing virulent micro-organisms within the antrum, without either condition being disclosed by the roentgenogram.

In my experience the most reliable investigative method for uncovering infections of the sinuses involves routine lavage of maxillary antrums and sphenoid sinuses. The best results can be obtained by following such a plan as closely as possible when searching for sources of unexplained headache and fever, for a focus in certain cases of meningitis or for foci of infection in a number of various systemic conditions (bronchitis, bronchiectasis, asthma, arthritis, neuritis, neuralgia, glomerulonephritis, labyrinthitis and inflammatory diseases of the uveal tract).

This suggestion invites the criticism that such an approach is too radical. It is the contention and experience of many rhinologists, however, that routine irrigation of the maxillary antrums and the sphenoid sinuses through the natural orifices or of the maxillary antrum through the membranous partition adjoining the middle meatus is relatively harmless and, as a rule, easily borne by the patient. I have seen residents at two institutions [5] become sufficiently trained and skilled in irrigation of the sinuses to meet the technical needs of such a procedure.

It is not within the scope of this paper to discuss the comparative merits of introducing a cannula through the middle and inferior meatuses or the complications associated with sinal irrigations and how to avoid them. Dintenfass [6] accomplished this ably in a paper published in 1932. He concluded that catheterization through the natural orifice is the procedure of choice but that it demands thorough knowledge of the anatomy of the lateral nasal wall together with skill and experience. It is difficult to understand how there can be grounds for argument after hearing the most favorable comments in favor of catheterization through the natural orifice from patients who have experienced both methods of antral irrigation.

It would be folly to claim that the procedure of irrigation of the antrums is unattended by possible complications, but it is entirely fair and correct to state that in competent and well trained hands these complications are usually inconsequential and occur with the infrequency incidental to most diagnostic procedures. The serious accidents which happen from lavage of the sinuses, especially the maxillary antrums, result from or are connected with the injection of air into the sinus under pressure. Unless one is certain that the cannula is freely movable within the cavity of the sinus, air should not be injected into the sinus. As further precaution, it is advisable that the air be

5. Laryngologic service of Dr. R. Kramer, the Mount Sinai Hospital, and otolaryngologic service of Dr. J. W. Fowlkes, Bellevue Hospital.

6. Dintenfass, H.: Inferior Meatal Puncture Versus Catheterization of Natural Orifice of Maxillary Sinus, Laryngoscope **42**:943 (Dec.) 1932.

introduced under the least pressure necessary to force out the residual solution or that the injection of air be omitted from the procedure entirely.

### THE BACTERIAL AND CELLULAR FINDINGS IN SINAL WASHINGS

The important issue in the relationship of the paranasal sinuses to systemic infections is concerned with the general significance of the nature of the washings obtained from sinuses which have been irrigated for diagnostic purposes. This consideration involves two questions which, for a better understanding of the relationship of sinusitis to systemic diseases, require solution: First, how are the washings obtained on irrigation of the maxillary antrums and sphenoid sinuses to be interpreted in relation to the local condition of the sinuses, and, second, can the mucous membrane of a sinus be diseased in the absence of evidence of infection in the washings from the sinus?

The interpretation of the clinical significance of washings from sinuses has been based largely on impressions and conjectures and not on investigative knowledge. It has been accepted generally that a return of clear fluid predicated absence of infection and that presence of secretion, whether purulent or mucoid or flaky, demonstrated infection of the mucous membrane. However, in recent years competent investigators, have contended that macroscopically clear washings from a sinus may contain bacteria and cellular evidence of infection (Balmer; Enlows and Alexander; Signy; Sewall and Hunnicutt). It has also been observed that secretions obtained from sinal washings have been free from bacteria and from cellular evidence of infection (Ashley and Frick; Balmer; Kistner; Sewall and Hunnicutt). Thus, some authors hold the view that the macroscopic presence or absence of secretion in a sinal washing may not answer the question of infection.

In 1931 Balmer [7] published his bacteriologic observations on normal and diseased maxillary antrums. He reported that the washings from several clinically normal antrums showed flakes and were slightly turbid but that the cultures of these washings were sterile. On the other hand, micro-organisms were obtained from the clear washings of twenty-seven antrums. It should be emphasized, however, that the cultures showed mixed infections as a rule and that the usual nonpathogenic micro-organisms, such as Staphylococcus albus and diphtheroids, were predominant. Enlows and Alexander [8] in a similar study published in 1936 reported that they obtained bacterial growth from the clear washings of thirty maxillary antrums. Streptococcus

7. Balmer, F.: The Relation of Clinical to Bacteriologic Observations in Normal and in Diseased Maxillary Antrums, Arch. Otolaryng. **14**:440 (Oct.) 1931.

8. Enlows, E. M., and Alexander, S. A.: Bacteriologic Studies in Acute and in Chronic Maxillary Sinusitis, Arch. Otolaryng. **23**:665 (June) 1936.

viridans was the predominant micro-organism and was isolated alone in 24 cases. The authors mentioned that the preponderant micro-organism from the middle and the inferior meatuses was the same as that from the maxillary antrum. There have been other similar studies in recent years, but much of the data is not appropriate for this discussion.

In 1919 Dean and Armstrong,[9] in their bacteriologic study of the maxillary antrums of children, found a close accord between macroscopic washings and cultural findings. They obtained growth of micro-organisms from the antrums which contained gross secretion. The micro-organisms usually encountered were staphylococci, but pneumococci and hemolytic streptococci, as well as diphtheroids and Micrococcus catarrhalis, were also obtained. An interesting fact is that of 12 patients with arthritis, the hemolytic streptococcus was isolated from the antrums of 11.

Ashley and Frick[10] in their paper published in 1930 reported the presence of cytologic elements, particularly mononuclear leukocytes, in cases in which micro-organisms were not obtained from sinal washings of the maxillary antrums. They expressed the opinion that such a cellular reaction indicated a chronic infection in the mucous membrane; this point of view was also shared by Kistner[11] and by Sewall and Hunnicutt.[12] These authors did not take into consideration the significance of mucus in sinal washings. I am aware that an infection may exist in the mucous membrane of an antrum although the secretion or flakes obtained by lavage are free from micro-organisms. Autolysis of micro-organisms, for instance, frequently occurs in stagnant secretion. Nevertheless, with the inadequate information and evidence available, the opinion that sterile secretion or flakes *always* indicate an infection of the mucous membrane is not warranted and should not be accepted at present, especially in view of the significance of such findings in relation to the problem of focal infection.

The studies and references cited in the foregoing paragraphs, although important contributions to the subject, do not offer conclusive evidence as to the meaning of macroscopic, microscopic and cul-

9. Dean, L. W., and Armstrong, M.: Nasal Sinus Disease in Infants and Young Children, Including Bacteriologic Study, Ann. Otol., Rhin. & Laryng. **28**:452 (June) 1919.

10. Ashley, B. J., and Frick, W. V.: A Bacteriologic and Cytologic Study of the Maxillary Antrum in Children with a Clinical Study of Eighty-Three Cases, Ann. Otol., Rhin. & Laryng. **39**:605 (June) 1930.

11. Kistner, F. B.: Chronic Nonpurulent Sinusitis and Its Clinical Significance, Ann. Otol., Rhin. & Laryng. **38**:795 (Sept.) 1929.

12. Sewall, E. C., and Hunnicutt, L.: Cytologic Examination of the Antrum: Review of Cases to Determine the Relationship Between Cytologic and the X-Ray and Pathologic Observations, Arch. Otolaryng. **10**:1 (July) 1929.

tural findings in sinal washings. But these investigations do show the different points of view concerning the significance of the appearance of sinal washings and the need for additional study of infections of the sinuses in order to determine their relationship to systemic disease. It is incumbent on rhinologists together with bacteriologists to obtain the necessary information.

A common omission in the examination of sinal washings is the microscopic study of spreads of the material obtained. To evaluate properly the nature of an infection of the paranasal sinuses it is necessary to study spreads of the sinal washings microscopically, besides culturing the fluid or secretion on both solid and fluid mediums. Secretion obtained in sinal washings on examination may prove to be sterile degenerated mucus, a conglomeration of epithelial debris and mucus or crystals of cholesterol admixed in mucus and the result of previous bacterial autolysis. I have found antral secretions from patients with bronchial asthma and nasal allergy to contain mucus and epithelial and polymorphonuclear cells with a great preponderance of eosinophils, but there was no evidence of micro-organisms on smear or culture. Then, again, flakes and small clumps of pus disclosed on examination micro-organisms in high concentration. The presence of myriads of micro-organisms, in chains or in pairs, or of large numbers of young polymorphonuclear cells has far greater significance than one or two scattered cocci or bacilli or a few mononuclear and epithelial cells, regardless of the macroscopic appearance of the fluid. A comparison of spreads and micro-organisms obtained by culture can prove to be most helpful in identifying the significant infectious agent.

It is also important to use solid as well as fluid mediums in making cultures of sinal washings. The growth of many colonies on a blood agar plate, particularly of a pathogenic micro-organism such as Streptococcus haemolyticus, Staphylococcus aureus or Pneumococcus, offers much more significant information than a broth tube filled with micro-organisms. For it must be realized that a few micro-organisms in a fluid medium will yield as high a concentration as many micro-organisms after a short period.

Many bacteriologic studies have shown that the flora of a normal nose is entirely different from the micro-organisms found in diseased sinuses and infected nasal passageways. Under normal conditions the predominant bacteria in the nose are usually Staph. albus, diphtheroids and M. catarrhalis. Pneumococci and streptococci, particularly the hemolytic variety, are rare. On the other hand, Str. haemolyticus and Str. viridans, the various pneumococci, Staph. aureus and occasionally Bacillus influenzae and Friedländer's bacillus are the usual micro-organisms encountered in infected sinuses. Staph. albus also might be considered a pathogenic micro-organism if it were to be

obtained repeatedly in pure culture from an infected sinus. It has been my experience that micro-organisms can often be grown in pure culture. Thus, any of the first mentioned group of bacteria in a sinal washing is likely to be a contaminant, and it is probable that cultures of sinal washings which grow several bacteria have been contaminated.

Routine bacteriologic investigations may ultimately lead to the recognition of distinct types of paranasal sinusitis, determined by the particular micro-organisms involved. There is reason to believe that the infectious process of a pneumococcic sinusitis may differ from that of a hemolytic streptococcic sinusitis just as a pneumococcic pneumonia differs from a hemolytic streptococcic pneumonia. It is possible that the various infectious agents found in cases of sinusitis may have dissimilar biologic effects on systemic diseases. It is pertinent to mention that in successive exacerbations of a sinal infection cultures may yield different micro-organisms. A bacteriologic distinction between types of sinusitis also will permit better development of specific chemical and immunologic therapy.

The method usually employed to obtain specimens from maxillary antrums for examination is to puncture the inferior antromeatal wall with a large needle (no. 19) or a trocar. The specimen, in saline solution, is aspirated into a glass syringe. The nose, of course, is prepared with antiseptic care, and sterile conditions are maintained. Dean and Armstrong,[9] Balmer[7] and Enlows and Alexander[8] collected their antral washings in this fashion. Watson-Williams[1] advocated a method which he termed "suction-exploration," i. e., the material within the sinus is aspirated into the syringe without the use of saline solution. These methods are also suitable for investigation of the sphenoid sinus.

When no macroscopic secretion is present the first method described is necessary if one is to determine the presence of infection. I have found another method satisfactory and expedient for culturing purulent and mucoid secretion or flakes in antral washings:

> The nares and the external surface of the nose are thoroughly cleansed and swabbed with 70 per cent alcohol. With sterile instruments and equipment the antrum is irrigated through the middle meatus, preferably through the natural orifice. From a sterile basin the desired secretion is aspirated into a sterile capillary pipet. The secretion is washed in sterile saline solution and then injected into fluid and deposited on solid mediums.

This method is simple enough to be available for routine office and hospital practice. With this technic we have obtained regularly pure cultures of pathogenic micro-organisms.

The best method in my experience for obtaining material for culture from diseased ethmoid cells is to apply the platinum loop directly to the infected area.

### RELATIONSHIP OF ROENTGENOGRAPHIC INDICATIONS TO SINAL WASHINGS

In addition to the problem of discovering infection within the cavity of the sinus, there is the question whether infection may reside in the layers of the mucous membrane of the sinus, though the washings appear clear and are even sterile. Watson-Williams,[1] Harper,[2] Grove and Cooke [13] and others have been successful in isolating micro-organisms from the mucous membranes of sinuses which were treated because of systemic disease. In some of the cases the sinuses were free from secretion, or, if secretion was present, micro-organisms did not grow on culture. In such cases, of course, roentgenologic examination, especially with radiopaque substances, is the diagnostic method most suitable to reveal the condition of the sinuses. The literature on the subject contains a number of reports of radical operations on the sinuses performed for the removal of infected foci the presence of which had been determined by roentgenographic findings. In these reports successful therapeutic results are cited.

There are rhinologists who hold the belief that maxillary antrums which appear clear on the roentgenogram do not yield pus or mucus on lavage. Signy,[14] for instance, made a study to determine this relationship and failed to obtain mucopus from sinuses with clear roentgenograms. Johnson,[15] in a report on the comparative value of roentgenographic and physical observations in 300 cases of maxillary sinusitis, stated that secretion was not found in any antrum which did not present either clinical or roentgenographic evidence of disease. Nevertheless, in 20 cases in which there were positive clinical but negative roentgenographic indications, investigations revealed that the antrums contained either thick mucus or mucopurulent clots or pus. However, as previously stated, I have obtained secretion from sinuses which gave no roentgenographic or clinical evidence of disease, and this has been the experience of physicians with whom I have been associated.

These observations give a clue as to the proper indication for the use of roentgenologic examinations in conjunction with diagnostic lavage. Though sinal washings are clear, it seems to me that roentgenologic studies are warranted in cases in which the problem of focal infection arises if the antrums are cloudy on transillumination or if there is intranasal evidence of disease or if there is a past history suggestive of infection of the paranasal sinuses. If in the presence of a systemic

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13. Grove, R. C., and Cooke, R. A.: Etiology and Nature of Chronic Hyperplastic Sinusitis, Arch. Otolaryng. **18**:622 (Nov.) 1933.

14. Signy, A. G.: Accessory Nasal Sinusitis in Childhood, Arch. Dis. Childhood **11**:281 (Dec.) 1936.

15. Johnson, H. P.: Diagnosis of Chronic Maxillary Sinusitis, Arch. Otolaryng. **5**:309 (April) 1927.

infection the roentgenogram reveals the mucous membrane of a sinus to be appreciably thickened and if diagnostic lavage yields clear microscopic as well as macroscopic washings, which are found to be sterile on culture, is this membrane to be considered as a potential focus of infection? That is a question which, I dare say, cannot be definitely answered by rhinologists at present because of inadequate data.

### THE GENESIS OF SYSTEMIC INFECTIONS

I should like to add some comments as to the role of infection of the sinuses in the genesis of bacteremia and systemic infections. Bacteria infecting the paranasal sinuses most probably affect distant organs by the elaboration of bacterial toxins and products which are absorbed into the circulation by lymph and venous channels. It is my opinion that, as a rule, infections limited to the cavities of the sinuses do not give rise to bacteremia, and, accordingly, the involvement of distant organs secondary to infection of the sinuses is not the result of bacterial metastasis. In 1936 I published a study [16] which strongly suggested that the demonstration of invasion of the blood stream in the presence of acute paranasal sinusitis indicated the coexistence of a complication or some associated systemic infection. Wood [17] in 1928 expressed the belief that the production of secondary infection by direct absorption of bacteria into the circulation from the paranasal sinuses is one of the rarest occurrences observed in medical practice. He mentioned the possibility that purulent secretion of the sinuses infects the highly absorptive lymphoid tissue of the nasopharynx and pharynx, which in turn may become the source of an invasion of the blood stream.

A possible explanation based on anatomic vascular structure may be offered for the failure of bacteremia to develop in cases of acute paranasal sinusitis unless the sinusitis is followed by complications. The veins that drain the mucous membrane of the paranasal sinuses and penetrate their bony cells may be so small that they become thrombosed and sealed off before bacteria can enter the general circulation. When a focus is set up in the skull, meninges or orbit by contiguous extension from sinusitis, however, invasion of the blood stream may then occur from an infection of the large veins which drain these sites. These veins because of their larger size do not thrombose so easily and are able to feed the general circulation repeatedly with showers of bacterial emboli. Similarly, bacteremia, in the presence of or following acute mastoiditis, usually indicates an infection of the lateral sinus or some other complication.

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16. Goldman, J. L.: Complications of Acute Sinusitis with Special Reference to Bacteremias, Laryngoscope **46**:500 (July) 1936.

17. Wood, V. V.: The Paranasal Sinuses as Sources of Infection, Ann. Otol., Rhin. & Laryng. **37**:592 (June) 1928.

The relationship of infections of the paranasal sinuses to general systemic infections provokes interesting considerations in the domain of immunology and bacterial allergy. It may be that repeated absorption into the circulation from an infected focus of active bacterial principles which are capable of sensitizing tissues may make the human organism susceptible to certain diseases, such as asthma, arthritis, neuritis and iritis. Once an organ becomes sensitized by bacterial toxins or other protein products, its state of hypersensitiveness may be maintained or aggravated by the same active bacterial principles, evolved by the original focus, by related bacterial principles from another focus of infection or by disorders of metabolism which throw off into the blood stream colloidal substances capable of allergic combinations. It seems possible that pathologic processes such as those mentioned result from the maintenance and aggravation of the superimposed reaction of the particular local tissue to the repeated insults of certain active bacterial and protein principles which circulate in the blood stream. Such reaction of tissue to foci of infection is suggested by certain particular phases of the phenomenon of local tissue reactivity described by Shwartzman.[18] Thus, it seems that in dealing with bacterial allergy it is first necessary to eradicate the offending focus, but if the disease process continues, other infected foci must be eliminated and even disturbances in the allergic and chemical metabolism of the body must be corrected.

## CONCLUSIONS

Diagnostic lavage is an important and most useful means of discovering infections of the paranasal sinuses, especially those of the silent variety. Observations in a limited group of cases indicate that the usefulness of this procedure would be considerably enhanced and the whole problem of sinusitis in relation to systemic disease would be greatly clarified if the following specific investigations were carried out and made routine studies as far as possible: (1) the interpretation and correlation of macroscopic, microscopic and cultural findings of sinal washings as indicated in this paper; (2) the correlation of such findings with roentgenologic observations on the sinuses and with pathologic observations on mucous membrane removed from the sinuses at operation, and (3) ultimately the correlation of this information with that on the clinical features of sinusitis and the various systemic pathologic conditions which can be affected by infection of the paranasal sinuses. Much important information pertaining to the problem of focal infection is yet to be revealed in the fields of bacteriology, immunology and allergy by the study and analysis in this fashion of infections of the paranasal sinuses.

12 East Eighty-Sixth Street.

18. Shwartzman, G.: Phenomenon of Local Tissue Reactivity, New York, Paul B. Hoeber, Inc., 1937, chap. 12.

# Case Reports

## INFECTED MUCOCELE OF THE FRONTAL SINUS, COMPLICATED BY SEPTICEMIA AND MENINGITIS, WITH RECOVERY

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Little has been written about mucoceles in the last decade. In 1935 Cavanaugh,[1] of Chicago, reported a case of mucocele of the frontal sinus with a train of ocular symptoms which continued over a two year period. He reviewed the causes of mucocele as portrayed in various textbooks and added his own theoretic explanation of the anomaly, "a misplaced ethmoid cell which becomes a mucocele due to some vitamin or endocrine unbalance."

Chamberlin and Parry,[2] of Cleveland, in 1933 reported 6 cases of patients with long-standing ocular symptoms who were operated on at the Lakeside Hospital. These physicians stated that "occlusion of the ostium from chronic inflammatory changes within the sinus or from pressure of a tumor such as an osteoma constitutes the main etiologic factor."

Mucocele of the frontal sinus is found fairly frequently at the Massachusetts Eye and Ear Infirmary, and is readily diagnosed with the aid of the roentgenologist, Dr. A. S. MacMillan.

It seems to me that an acceptable cause, which has long been mentioned and which microscopic study bears out, is "a cystic dilatation of a mucous gland," whether the mucocele is confined to the frontal sinus or is located primarily in a frontoethmoid or ethmoid cell. Certainly the roentgenograms in the case presented here do not show the whole of the frontal sinus to be filled. This constitutes a refutation of the theory that occlusion of the duct makes a mucocele of the whole sinus.

Microscopically the mucocele is a thin-walled sac made up of fibrous tissue with edema and lined by low cuboidal or stratified columnar epithelium; normally the frontal sinus and ethmoid cells are lined by a pseudostratified columnar ciliated epithelium.

Pressure must be the sole factor in eroding bone, and that pressure does not have to be great if it is constant.

You can see in the roentgenograms of the patient in the case presented here that the interfrontal partition was eroded even though the infected mucocele (pyocele) did not completely fill the frontal sinus from which it arose.

I am reporting this case because of the unusual lack of symptoms and signs until one week before operation, because it illustrates the advantage of roentgenologic over clinical and nasopharyngoscopic examination in certain instances in which there is severe headache and because of the interesting but discouraging complication of septicemia and meningitis, from which the patient recovered.

1. Cavanaugh, J. A.: Mucoceles of Frontal Sinus, Laryngoscope **45**:205-214 (March) 1935.

2. Chamberlin, W. B., and Parry, T. L.: Mucocele as Cause of Proptosis: Report of Six Cases, Arch. Otolaryng. **18**:172-180 (Aug.) 1933.

I think it may be helpful to others who find it necessary to treat pneumococcic meningitis to report this case in detail, as all physicians recognize the masking effects of chemotherapy. In this case the temperature ranged for fifteen days postoperatively from 99 to 102.8 F. daily. The chemotherapy unquestionably kept the temperature down, even though the dosage was inadequate for the first thirteen of the fifteen days.

### REPORT OF A CASE

*Present Illness.*—A 49 year old man complained of frontal headache of six days' duration. The headache was severe, coming on in the morning and disappearing at night. He had suffered no infection of the upper respiratory system. Examination of the ears, nose and throat gave negative results. Roentgenograms of the sinuses, however, showed a mucocele in the right frontal sinus, which had eroded the interfrontal partition and occupied a considerable part of the left frontal sinus.

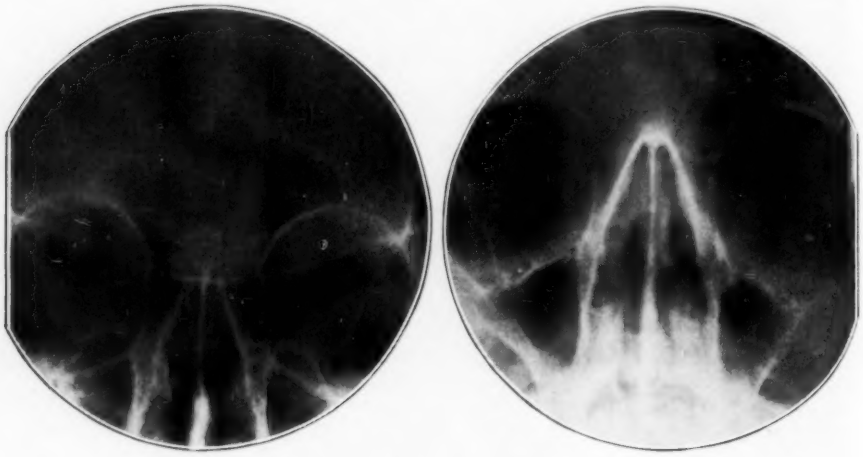

Fig. 1.—Roentgenograms of the frontal sinuses.

*History.*—The patient had suffered an attack of pneumonia twenty-eight years previously. Fourteen years before examination he had had an appendectomy and twelve years before examination, a tonsillectomy and adenoidectomy. His general health had been good except for slight dyspnea on exertion, which was ascribed to gradual gain in weight. Sacroiliac back strain had bothered him intermittently.

*Physical Examination.*—The head and eyes were normal. The teeth were false; the tonsils had been removed. The pharynx was slightly injected. There was no nasal discharge. The heart was not enlarged; the sounds were regular and of good quality; there were no murmurs. The blood pressure was 115 systolic and 80 diastolic. The lungs were resonant throughout. The breath sounds were vesicular, but asthmatic rales, which cleared on coughing, were present over both sides posteriorly.

*Operation.*—Jan. 4, 1940 a right external radical frontal operation was performed by the Lynch method. The usual supraorbital incision was made in the eyebrow and was carried down along the nose. The ethmoidal plate was soft and osteo-

myelitic. The ethmoid cells contained necrotic granulations, and the floor of the frontal sinus was decalcified and soft. When the floor of the frontal sinus was removed a large pyocele sac was found, which extended across the middle line into the left frontal sinus. A complete removal of the floor and orbital prolongations of the frontal sinus was done.

The upper portion of the nasal septum was removed according to Lothrop for more adequate drainage, and on the right side the cells in the anterior two thirds of the ethmoid sinus were removed.

*Postoperative Course.*—On January 5, the day following operation, the temperature rose to 101.3 F. On the day following that, at 3:40 a. m. the patient had a severe shaking chill with a temperature of 102 F., a pulse rate of 120 and considerable frontal headache. All of the reflexes were normal. Blood was taken for culture, and the administration of sulfapyridine (2-[paraaminobenzene sulfonamido]-pyridine) was started. A roentgenogram of the chest did not show a pathologic condition. The report from the culture of the pyocele was Pneumococcus type XXVIII.

On January 7, 80,000 units of type XXVIII rabbit serum was administered intravenously. At this time the neck was moderately stiff; the reflexes were equal on both sides. Babinski's sign was absent. There was some dull generalized headache. Lumbar puncture revealed an initial pressure of 350 mm. of water and a final pressure of 300 mm. of water; the fluid was slightly bloody and had a slight ground glass appearance. The white blood cell count was 4,800 per cubic millimeter, all polymorphonuclears. The protein was 242 mg. per hundred cubic centimeters and the sugar 66 mg. The colloidal gold curve was 000,21000.

On January 8 the patient was showing some improvement, but the neck was slightly stiff and there was some dull headache. Kernig's sign was slightly positive bilaterally.

On January 10 the laboratory reported that the blood was positive for Pneumococcus type XXVIII.

On January 12 the patient was clinically better, but the tendon reflexes on the right were more active than those on the left, and the left optic disk appeared hazy. The neck was still moderately stiff. Lumbar puncture yielded a cloudy, slightly xanthochromic fluid. The initial pressure was 600 mm. of water; after withdrawal of 10 cc. the pressure was 450, and the final pressure was 360. The white blood cell count was 3,140, with 92 per cent polymorphonuclears and 8 per cent lymphocytes. The protein content was 300 mg. per hundred cubic centimeters and the sugar content 20 mg. The sulfapyridine content was 4.82 mg. per hundred cubic centimeters. The increased pressure, persistence of cells and low sugar content suggested continuation of meningeal infection. The patient was given 500 cc. of whole citrated blood, preceded by 5 Gm. of sulfapyridine in 100 cc. of physiologic solution of sodium chloride, administered intravenously. The urine on this date was loaded with sulfapyridine crystals.

On January 13 both optic disks were slightly blurred, and the reflexes on the right side were unquestionably more active than those on the left. Lumbar puncture released spinal fluid under an initial pressure of 350 to 400 mm. of water; the final pressure was 200 mm. There were 1,270 white blood cells, with 89 per cent polymorphonuclears and 11 per cent lymphocytes. The protein content was 166 mg. per hundred cubic centimeters and the sugar content 15 mg. The sulfapyridine content was 6.42 mg. The urine continued to show numerous sulfapyridine crystals.

On January 14 the patient complained of deafness. Both optic disks were blurred, and the physiologic cup on the left disk was almost obliterated. The radial, biceps and knee reflexes on the right side were more active than those on the left side. Lumbar puncture showed an initial pressure of 350 mm. of water; the final pressure was 150 mm. The fluid was cloudy; the white blood cell count

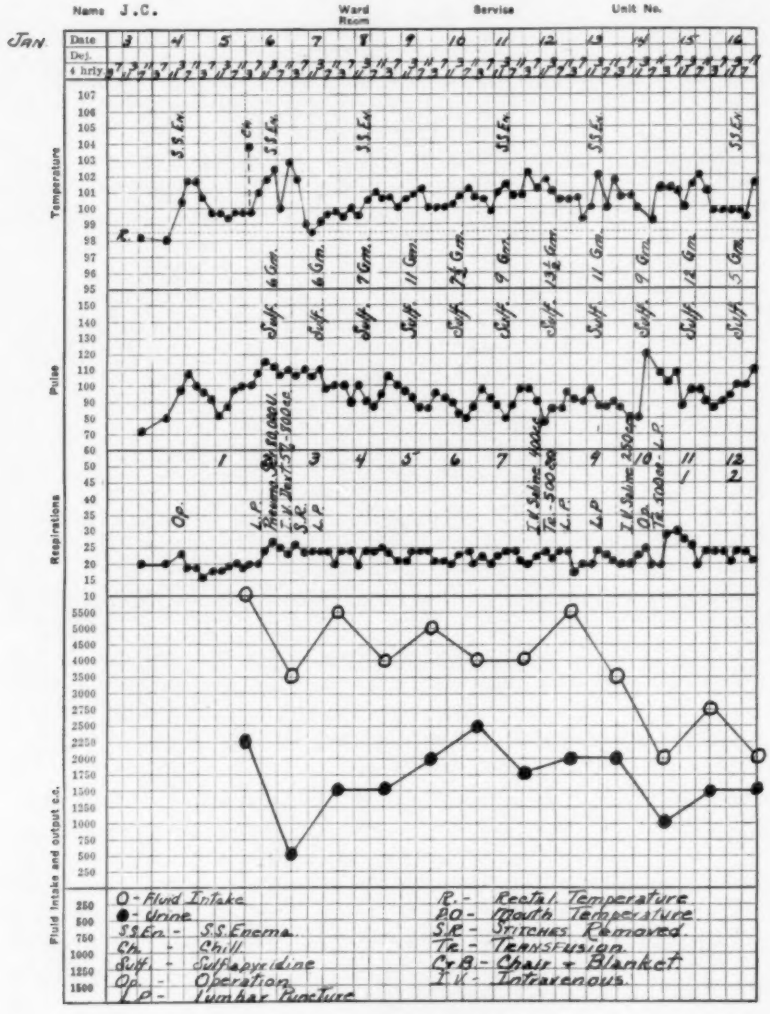


Figure 2

Figs. 2 to 5.—Charts showing the patient's treatment and progress.

was 1,520, with 1,225 polymorphonuclears, 225 lymphocytes and 40 large mononuclears; there were 5 red corpuscles. The protein content was 228 mg. per hundred cubic centimeters and the sugar content 16 mg. The sulfapyridine content was 3.62 mg. per hundred cubic centimeters.

*Second Operation.*—On January 14 a secondary radical external frontal operation was done. Bilateral external frontal operation with removal of the posterior bony walls was carried out, as there was some question of the presence of an epidural abscess. The anterior walls of both frontal sinuses were removed. This was

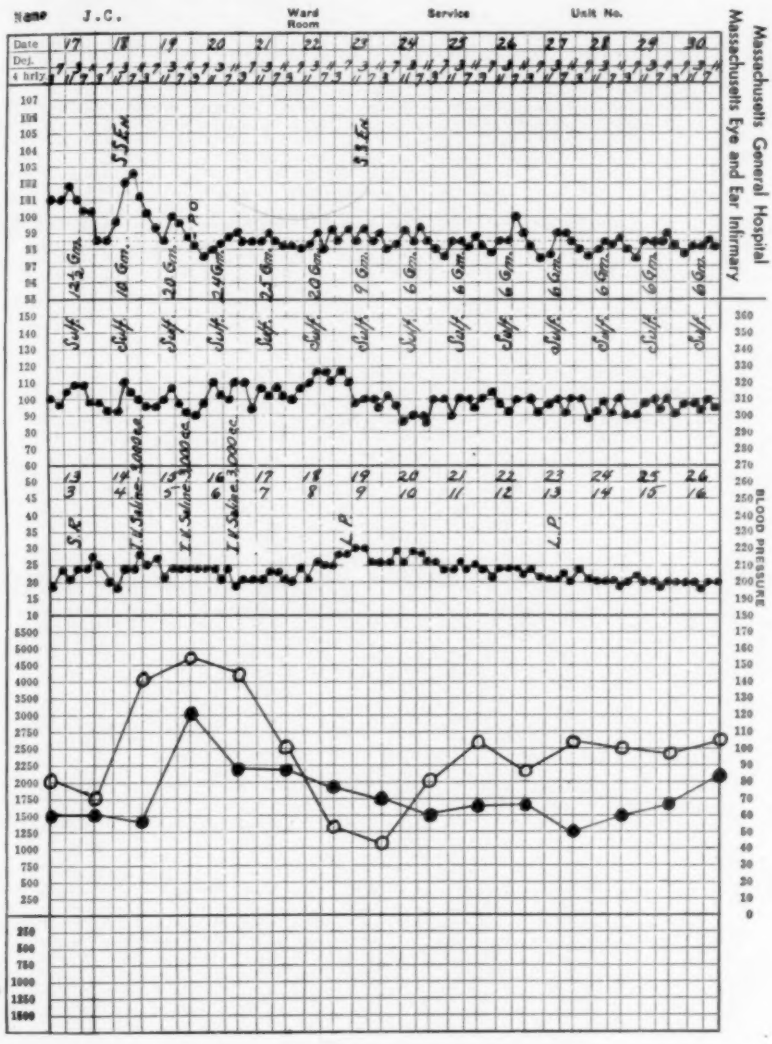


Figure 3

necessary in order to have sufficient room to remove the posterior walls in search for an epidural abscess or extension of meningitis. The posterior bony wall was removed for an area of about the size of a fifty cent piece on each side, and there was no evidence of any inflammatory reaction in the dura. The dura was

separated well beyond this exposure on each side, and no inflammation or pus was encountered. The region of the cribriform plate appeared perfectly intact and normal.

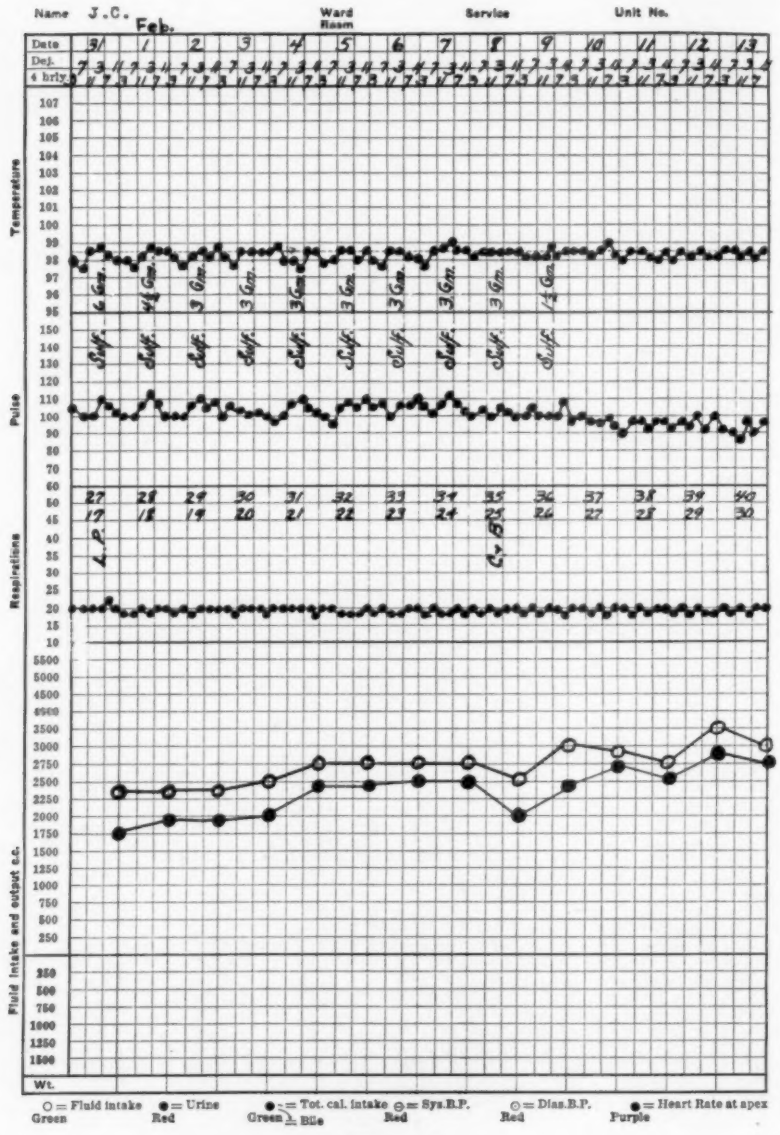


Figure 4

I was convinced that the meningitis was transmitted through an infection of the blood stream. Nothing was done to the left ethmoid region, as the nasal septum had been taken down and there seemed adequate room for drainage of the left frontal sinus, as well as of the right.

*Postoperative Course.*—On January 15 the patient had no headache or backache, although Kernig's sign was present bilaterally. The reflexes in the right arm and leg were slightly more active than those in the left arm and leg. The urine continued to be loaded with sulfapyridine crystals.

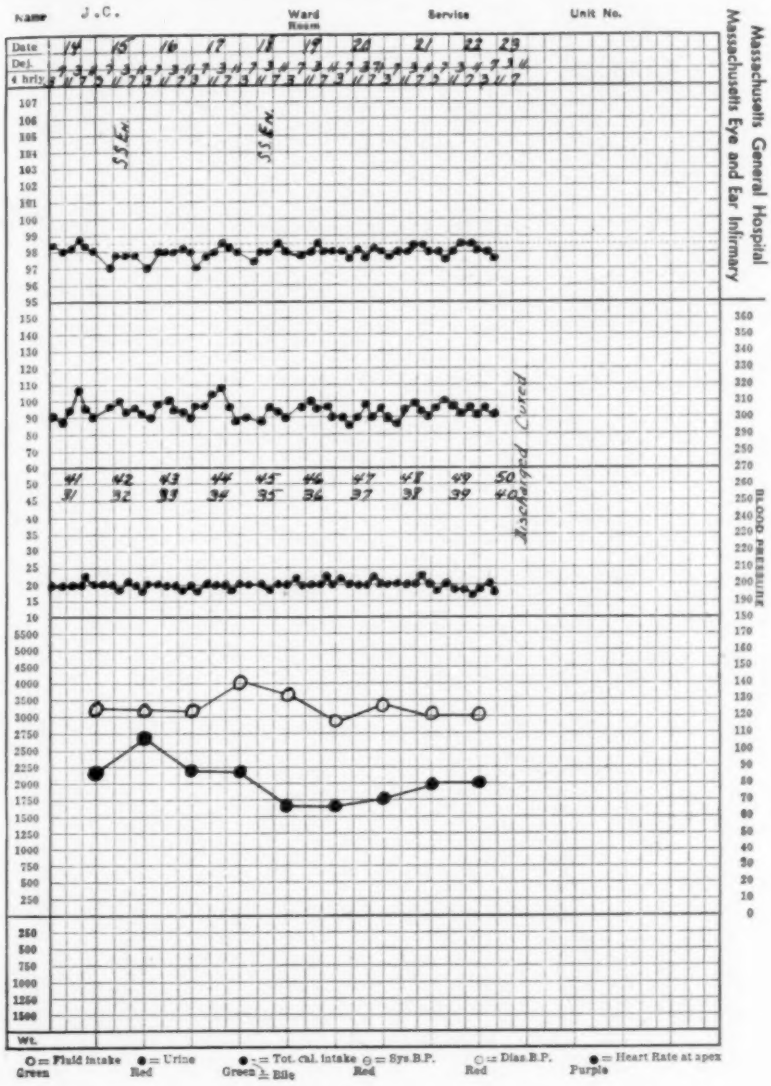


Figure 5

On January 20 the output of urine was increased because of the intravenous medication. The difficulty in raising the level of sulfapyridine in this man's blood was attributable to rapid urinary excretion of the drug because of (1) the free sulfapyridine of 3.6 mg. and the conjugated sulfapyridine of 3.6 mg. per hundred

TABLE 1.—*Sulfapyridine Dosage*

| Date | Grams | Date | Grams | Date | Grams |
|---|---|---|---|---|---|
| January 6 | 6 | January 18 | 10 | January 30 | 6 |
| 7 | 6 | 19 | 20 | 31 | 6 |
| 8 | 7 | 20 | 24 | February 1 | 4½ |
| 9 | 11 | 21 | 25 | 2 | 3 |
| 10 | 7½ | 22 | 20 | 3 | 3 |
| 11 | 9 | 23 | 9 | 4 | 3 |
| 12 | 13½ | 24 | 6 | 5 | 3 |
| 13 | 11 | 25 | 6 | 6 | 3 |
| 14 | 9 | 26 | 6 | 7 | 3 |
| 15 | 12 | 27 | 6 | 8 | 3 |
| 16 | 6½ | 28 | 6 | 9 | 1½ |
| 17 | 12½ | 29 | 6 | | |

TABLE 2.—*Data on Case*

| Date | White Blood Cells | Red Blood Cells | Hemoglobin Content of the Blood, per Cent | Polymorphonuclears, per Cent | Blood Sulfapyridine Level, Mg. per 100 Cc. | Spinal Fluid Sulfapyridine Level, Mg. per 100 Cc. |
|---|---|---|---|---|---|---|
| 1/ 6 | 36,700 | 4,890,000 | 12.3 | 95 | ... | .... |
| 1/ 8 | ..... | ..... | .... | .. | 3.9 | .... |
| 1/ 9 | 38,400 | 3,900,000 | 16.4 | 96 | 3.8 | .... |
| 1/10 | 22,300 | ..... | .... | 77 | 2.4 | .... |
| 1/11 | 21,500 | ..... | 11.1 | 84 | 3.6 | .... |
| 1/12 | 20,500 | ..... | 9.8 | .. | 3.0 | 4.82 |
| 1/13 | 21,800 | ..... | 11.1 | .. | 4.2 | 6.42 |
| 1/14 | 22,900 | 3,290,000 | .... | 82 | ... | 3.62 |
| 1/15 | 23,000 | ..... | 10.9 | .. | Trace | |
| 1/16 | 8,500 | ..... | 11.7 | 78 | 5.3 | |
| 1/17 | 25,000 | ..... | 11.5 | 82 | 2.9 | |
| 1/18 | 17,700 a.m.<br>21,100 p.m. | ..... | 11.5 | 77 | 4.5 | |
| 1/19 | 19,500 a.m.<br>19,900 p.m. | ..... | 11.1 | 85 | 3.6 | |
| 1/20 | 13,200 a.m.<br>15,800 p.m. | ..... | 10.7 | 82 | 11.1 | |
| 1/21 | 17,700 a.m. | ..... | 10.7 | 73 | 6.9 | |
| 1/22 | 13,100 a.m.<br>16,800 p.m. | ..... | 11.3 | 82 | 8.3 | |
| 1/23 | 17,400 a.m.<br>22,500 p.m. | ..... | 10.7 | 88 | 5.3 | |
| 1/24 | 21,800 | ..... | 11.3 | .. | | |
| 1/25 | 18,200 | ..... | 11.9 | .. | | |
| 1/26 | 22,100 | ..... | 11.3 | .. | | |
| 1/27 | 16,300 | ..... | 11.9 | 86 | | |
| 1/28 | 21,500 | ..... | 12.3 | .. | | |
| 1/29 | 14,400 | ..... | 11.1 | .. | | |
| 1/30 | 19,300 | ..... | 10.7 | .. | | |
| 1/31 | 15,600 | ..... | 11.7 | .. | | |
| 2/ 1 | 12,900 | ..... | 11.3 | .. | | |
| 2/ 2 | 13,600 | ..... | 11.9 | .. | | |
| 2/ 3 | 14,900 | ..... | 12.5 | .. | | |
| 2/ 4 | 14,900 | ..... | 12.0 | .. | | |
| 2/ 5 | 15,300 | ..... | 12.7 | .. | | |
| 2/ 6 | 13,300 | ..... | 13.6 | .. | | |
| 2/ 7 | 9,700 | ..... | 12.7 | .. | | |
| 2/ 8 | 8,600 | ..... | 12.3 | .. | | |
| 2/ 9 | 8,500 | ..... | 12.5 | .. | | |
| 2/10 | 11,300 | ..... | 13.0 | .. | | |
| 2/12 | 10,800 | ..... | 15.6 | .. | | |
| 2/15 | 14,500 | ..... | 13.9 | .. | | |
| 2/17 | 19,800 | ..... | 14.1 | .. | | |
| 2/19 | 20,300 | 4,330,000 | 80(T) | 64 | | |
| 2/20 | 20,000 | ..... | 16.7 | .. | | |
| 2/21 | 23,700 | ..... | .... | 82 | | |
| 2/22 | 21,200 | ..... | .... | 77 | | |
| 2/23 | 19,400 | ..... | .... | .. | | |
| 2/26 | 13,000 | ..... | .... | 66 | | |

cubic centimeters in the blood following large intravenous doses and (2) the heavy output in the urine. Therefore for the next twenty-four hours he was given medication by mouth as follows: 2 Gm. at 8 a. m., 10 a. m., 12 m., 2 p. m., 4 p. m., 6 p. m., 8 p. m., 10 p. m., 12 p. m. and 4 a. m. After this dosage the neck became less stiff; the patient had no nausea and did not vomit; there was no jaundice, and the liver and spleen were not palpable.

On January 22 the patient showed some apathy and confusion, but, aside from slight deafness and unexplained tachycardia and a few atelectatic rales at the base of each lung, his physical examination revealed nothing abnormal.

On January 23 the neck was no longer stiff, but Kernig's sign was slightly positive bilaterally. Lumbar puncture showed an initial pressure of 420 mm. of water and a final pressure of 200 mm. The spinal fluid was cloudy and slightly yellow. The total white blood cell count was 1,090, with 90 per cent polymorphonuclears and 10 per cent lymphocytes. The total protein content of the spinal fluid was 684 mg. per hundred cubic centimeters and the total sugar content, 59 mg.

On January 27 lumbar puncture showed an initial pressure of 160 to 200 mm. of water and a final pressure of 120 mm. The fluid was slightly xanthochromic and slightly cloudy. The total white blood cell count was 250, with 87 per cent polymorphonuclears and 13 per cent lymphocytes. The total protein content was 480 mg. per hundred cubic centimeters, the total sugar content 48 mg. and the total chloride content 651 mg. There was a trace of sulfapyridine.

On January 31 the neurologic examination gave negative results, and a lumbar puncture showed slightly cloudy and xanthochromic fluid under an initial pressure of 200 to 250 mm. of water and a final pressure of 160 mm. It contained 110 polymorphonuclears, 73 lymphocytes and 21 large mononuclears, a total of 204 white blood cells. The total protein content was 666 mg. per hundred cubic centimeters, the total sugar content 60 mg. and the total chloride content 679 mg.

From this point on, with the exception of some midline pain, in the lower part of the back the patient improved daily. Roentgenograms of his kidneys and pelvis revealed no abnormality, and the backache disappeared as the patient grew stronger and more active.

A total of 292.5 Gm., or 4,388 grains, of sulfapyridine was given over a period of thirty-five days. The patient was in the hospital fourteen days longer and was discharged on the fiftieth day (February 26) as cured.

## COMMENT

The treatment with sulfapyridine and rabbit serum under the direction of Dr. Champ Lyons is particularly instructive. A blood culture taken before the treatment with sulfapyridine was started showed the presence of Pneumococcus type XXVIII. The patient had only seven lumbar punctures, after two of which Pneumococcus type XXVIII was recovered from the spinal fluid. The reason that so few lumbar punctures were made was that the sulfapyridine held the pneumococcic infection in attenuated virulence, keeping the temperature and the spinal fluid pressure low, even though neurologic signs of meningitis were marked.

Only two transfusions were given, as the blood-forming organs were not greatly affected.

Daily urinalyses showed numerous sulfapyridine crystals, but there was never any anuria or hematuria, and even though a large part of the drug was acetylated and passed through the kidney as crystals, the dosage was never decreased on that account.

Dr. Lyons postulates that if there is an optimum blood level of sulfapyridine or sulfanilamide, depending on whether one is combating a pneumococcus or a streptococcus, and there are specific antibacterial antibodies in the patient's blood stream, the temperature in any given case should become normal in forty-eight hours unless there is (1) a collection of pus present, (2) vascular disease (thrombosis or thrombophlebitis or endocarditis), (3) drug toxemia or (4) scarlet fever.

In the case reported, the temperature was normal forty-eight hours after Dr. Lyons had pushed the blood sulfapyridine level up to 6 mg. per hundred cubic centimeters with tremendous doses of the drug, as may be seen in the chart.

The second operation was done to rule out an extradural abscess or osteomyelitis of the posterior bony wall of the frontal sinuses that might have been feeding the meningitis, but an adequate blood level of sulfapyridine would have made this second operation unnecessary.

# DERMOID CYST OF THE NASAL SEPTUM

## Intranasal Excision

ARTHUR L. JUERS, M.D., LOUISVILLE, KY.

The most recent case report of dermoid cyst of the nose in American literature was made by Hagens [1] in 1938. His article included a complete review of the literature, which revealed that only 3 similar cases had been reported in America. More cases had been reported in European literature. Luongo,[2] with his report of a case, reviewed the genesis of these cysts. In most cases previously reported the cyst has been in the upper portion of the nose, and the location necessitated an external operative approach. The case to be reported here differed in

Lateral roentgenogram, showing a probe in the fistula and cyst. The outline of the nose was added to show the relation of the probe to the soft tissues.

that the cyst was confined to the cartilaginous portion of the septum and the fistula opened between the two lower alar cartilages on the dorsum of the nose.

### REPORT OF A CASE

The patient was 19 years of age, and on a few occasions during childhood the fistula had apparently closed, requiring incision of the cyst to relieve the retention of secretion and the secondary inflammatory process. A probe could readily be passed into the cyst, as is shown in the accompanying roentgenogram. Iodized poppyseed oil was injected through a small cannula, but since the cyst was completely filled with debris, not enough of the oil was retained to show the extent of the cyst on roentgen examination. With the region under local anes-

1. Hagens, E. W.: Congenital Dermoid Cyst and Fistula of Dorsum of Nose: Report of Case, Arch. Otolaryng. **28**:399 (Sept.) 1938.

2. Luongo, R. A.: Dermoid Cyst of Nasal Dorsum, Arch. Otolaryng. **17**:755 (June) 1933.

thesia, an intranasal intercartilaginous incision was made on the right side and carried slightly over the septum, as in the initial step of a rhinoplastic operation for removal of a nasal hump. The fistula, which had previously been injected with methylthionine chloride (methylene blue), was readily identified and was excised in both directions from the point of encounter. The dermoid cyst was found in the septal cartilage, which was divided at this point into two wings enclosing it, and was easily removed. The wing of cartilage on the right of the cyst was removed by submucous resection, and its mucoperichondrium approximated against the remaining portion of cartilage, which was near the midline and in position to give adequate support to the tip of the nose. The cyst was filled with caseous material containing many fine hairs.

# Clinical Notes; New Instruments and Technics

## A NEW METHOD AND A NEW DEVICE FOR BRONCHOESOPHAGOSCOPY

E. I. Matis, M.D., Kaunas, Lithuania

A new method and a new device to provide combined proximal and distal lighting for bronchoesophagoscopic procedures are designed to accomplish the following purposes: 1. To enable one to use tubes of various lengths during a bronchoesophagoscopic operation without the necessity of reintroducing the instrument. The tubes can be changed quickly and without discomfort to the patient. The principle of extending tubes has been rejected. 2. To permit the use of tubes of suitable length for bronchoesophagoscopic examinations and operations. 3. To increase the working lumen of the tubes. 4. To permit the use of proximal and distal illumination under the most favorable conditions.

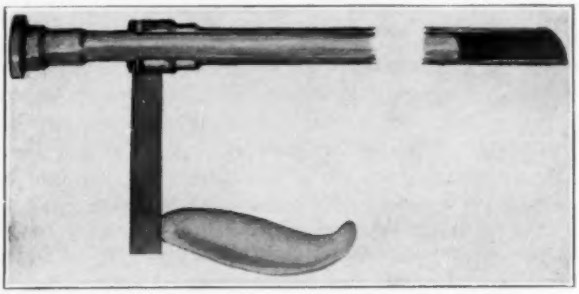

Fig. 1.—The shutter-slot operation: The shutter is withdrawn, leaving a lateral slot.

The aims have been achieved by the construction of a simple device which allows tubes of various lengths to be changed without the necessity of reintroduction of the bronchoesophagoscope and permits the diameter of the tubes to be increased without the use of any special mechanism like an expanding esophagoscope. On the right side of the bronchoesophagoscope is a shutter, which can be withdrawn (fig. 1), leaving a lateral slot. This permits introduction of a tube of the desired length and withdrawal of the one formerly in use. This slot also permits introduction of a shutter of another shape, thus considerably increasing the diameter of the same tube. The extensive regulation of the illumination, length and diameter of the bronchoesophagoscopic instruments makes possible a new method of bronchoesophagoscopic examination, allows a more elastic and individual use of the bronchoesophagoscope and increases the possible operative range.

### ILLUMINATION

In bronchoesophagoscopic procedures, the method of illumination is an important factor, on which the further improvement of the instrument depends. There are two methods of illumination—proximal and distal—each of which possesses different merits.

In the view of Jackson and Jackson,[1] distal lighting has the following qualities: "It is the only form of illumination that remains undiminished throughout all proceedings, because the source of light is in almost direct contact with the operative field. It is the only method that is completely independent of the proximal orifice of the bronchoscope, through which passes not only the visual axis but also the different instruments he (the otolaryngologist) employs. It is the only method that permits the introduction of instruments without diminution of lighting; the operating field, brilliantly illuminated by the lamp almost in contact with it, retains its entire visibility through the narrowest chink that may remain between the forceps and the wall of the bronchoscope. Finally, it is the means that by reason of the excellence of its lighting permits the employment of the tubes of the smallest size when in a given case it is essential to use the smallest possible tube."

The greatest advantage of proximal lighting is that the illumination is deep. The contrary is true of distal lighting.

Both systems of lighting have their opponents. For example, Jackson and Jackson[1] have spoken against proximal lighting, and Haslinger[2] and von Eicken[3] against distal illumination. The former remarked: "It was after many trials and for various reasons that we abandoned proximal illumination. . ." and again "with elongating tubes that utilize proximal lighting the intensity of illumination diminishes as the length of the tube is increased." Von Eicken considered as a disadvantage of distal lighting the fact that the illumination is not deep.

The system in which proximal and distal lighting are combined has not received general recognition. The special tube made by Hautant for both types of illumination is not particularly well known. However, on the grounds of favorable data I came to the conclusion that a combination of distal and proximal lighting has considerable advantages, and in 1933 I[4] became a supporter of it. It was further supported by Waldapfel[5] Soulas[6] and Irwin Moore. An instrument for proximal illumination was constructed by me in this way: The optical portion of the instrument, based on the principle of the forehead lamp, is adapted to all illuminating apparatuses for proximal illumination (Bruenings,[7] Kahler, Haslinger,[2] Irwin Moore) and consists of a lens, such as that of the forehead lamp, for the condensation of light rays and a mirror for the reflection or projection of the light to the extremity of the tube. The method of distributing the light rays to the tube is the most important factor in the various systems of illumination. One

1. Jackson, C.; Jackson, C. L., and Vialle, J.: La bronchoscopie, dans les affections broncho-pulmonaires, Paris, Les editions Delmas, 1936.

2. Haslinger, cited by Waldapfel.[5]

3. von Eicken, C.: Ueber die Fortschritte auf dem Gebiet der direkten Untersuchungsmethoden, Zentralbl. f. Hals-, Nasen- u. Ohrenh. **7**:545, 1925.

4. Matis, E. I.: Neue Instrumente zur Innenbeleuchtung und zur Dauerdrainage bei Broncho-Oesophagoscopie, Ztschr. f. Hals-, Nasen- u. Ohrenh. **33**:437, 1933; Comment on peut accomoder l'éclairage distal d'un broncho œsophagoscope avec l'éclairage proximal, Acta oto-laryng., to be published; Ueber die verschiedenen Beleuchtungsprinzipien bei der Broncho-Osophagoskopie, Monatschr. f. Ohrenh. **69**:409, 1935.

5. Waldapfel and Back, F. G.: Ueber die physikalisch-technischen Grundlagen der Beleuchtungsapparate für Endoskopie der oberen Luft- und Speisewege, Monatschr. f. Ohrenh. **69**:1439, 1935.

6. Soulas, A.: Œsophagoscopes (démonstrations pratiques sur chien chloralosé), Bronchoscop., œsophagoscop. et gastroscop., 1936, p. 6.

7. Denker, A., and Bruenings, W.: Lehrbuch der Krankheiten des Ohres und der Luftwege, ed. 8-9, Jena, Gustav Fischer, 1923, p. 606.

(Bruenings [7]) expressed a preference for a mirror which supplies a larger surface and provides a more powerful light, even though it obstructs the field of operation and interferes with the free manipulation of instruments under direct inspection. Another (Haslinger [2]), rejecting the full projection of light, stated that he preferred to have a free and easy passage for instruments. Waldapfel criticized Haslinger's and Bruening's systems, indicating their disadvantages.

The new device described here is supplied with a mirror and with a regulating mechanism which allows various positions of the mirror, thus giving the utmost range of light projection and allowing the use of both illuminating principles at the wish and convenience of the examiner. By the adjustment of two screws, the mirror can be directed into such a position that it provides a powerful light. If a free manipulation of instruments under direct inspection is required, the mirror can be held in such a position that a free and easy passage of instruments is secured. For distal illumination, a little terminal lamp and light carrier are used.

For orientation and for a general examination of the upper air and digestive passages, for procedures carried out with short and wide tubes, for the extraction of foreign bodies from the upper part of the esophagus and in cases of great secretion or bleeding I use proximal illumination. For a more detailed examination of the upper air and digestive passages, for procedures carried out with long and narrow tubes and for the exploration of the distal bronchi I use distal illumination.

## REGULATION OF LENGTH OF TUBE

An important factor in bronchoesophagoscopic procedure is convenience in the use of tubes of the required lengths. What is more, the shorter the tubes, the easier the technic and the more bearable to the patient is their introduction. Until the present, special extensions have been the only means of regulating length of tube, but owing to the inconvenience of this system, many (Jackson and Jackson,[1] Soulas,[8] Ganuyt and others) have either rejected this principle or chosen at random a tube of the required length or one considerably longer than is warranted and in this manner repudiated the principle of using tubes of the minimum length. Among the more important disadvantages of extending tubes are: (1) Elongation decreases the diameter of the tube; (2) the manipulation of instruments becomes more inconvenient and (3) it is impossible to introduce a narrow tube such as that required for the examination of the distal bronchi. But the most important disadvantage is that with extending tubes the length of the bronchoesophagoscope is unknown, and this makes it more difficult to judge the distance to the spot requiring examination. Bronchoesophagoscopic examination is carried out under monocular vision, which prevents use of the delicate judgment necessary for the estimation of depth. When working with tubes and instruments of definite lengths, it is easier to become accustomed to a sense of depth with monocular vision. My system permits freedom in the choice of tubes for each case and also permits one to change the tubes of various sizes. As a rule I use tubes each of which varies from the other in length by 5 cm., e. g. tubes of 30, 35 and 40 cm. length. A tube narrower than that originally inserted may also be introduced. The proximal and distal ends of the tubes are so constructed that they do not interfere with the insertion of one tube through another.

8. Matis, E. I.: Der erste Schritt zur Konstruktion eines parallel spreizbaren Broncho-Ösophagoskopes, Monatschr. f. Ohrenh. **70**:929, 1936; Un nouvel œsophagoscope dilatable, Bronchoscop., œsophagoscop. et gastroscop., 1936, p. 14; Was wird mit der Konstruktion des spreizbaren Broncho-Ösophagoskopes bezweckt? Acta oto-laryng. **25**:61, 1937; Use of Expanding Esophagoscope for Extraction of Foreign Bodies, Arch. Otolaryng. **31**:283 (Feb.) 1940.

### REGULATION OF WORKING LUMEN OF TUBES

To decrease the diameter of the tubes is difficult. At first a complicated device was made in order to widen the bronchoesophagoscope (Hill, Dufourmentel). I constructed an expanding bronchoesophagoscope for special cases.[8] However, efforts to increase the working lumen of an ordinary bronchoesophagoscope have not yet succeeded. Using the principle of shutter and slot, I have been able to find a simple means of increasing the working lumen of the ordinary tube on a relatively wide scale. For this, no special mechanism is required. For any examination the shutter can be withdrawn and another, with a more nearly round shape, can be inserted, thus considerably increasing the size of the tube, the shape of which has now been changed from circular to oval (fig. 2). This act of increasing the lumen of the tube takes place during the esophagoscopic procedure without any particular difficulty, since the shape of the esophagus is also oval. This principle of the regulation of the lumen of the tube is of particular importance in the extraction of foreign bodies.

### INSTRUMENTS AND EQUIPMENT

Bronchoscopic and esophagoscopic examination with my system require newly constructed instruments which are rather complex and somewhat numerous.

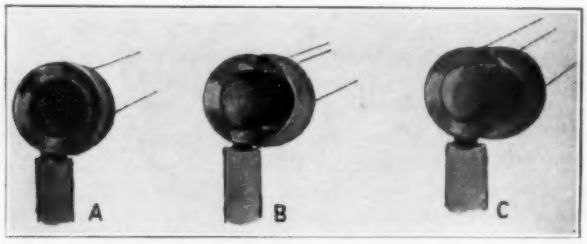


Fig. 2.—The increasing lumen of the tube, the shape of which has been changed from circular (*A*) to oval (*B* and *C*).

*Endoscopic Tubes.*—There are two types of endoscopic tubes: (1) those that have to be changed during examination and in which, if necessary, the working lumen is increased and (2) those which are used for final examination and which do not need to be increased in size.

The first of these is easier of introduction and is more convenient for use in general orientation, for examination of the upper parts of the esophagus and the respiratory tract and for bronchoesophagoscopic operations.

The basic tubes are 23 to 25 cm. in length and 10 to 12 or 13 mm. in diameter. These have a lateral slot along their whole length, which is closed by a shutter, and each one has shutters of several shapes, which can be inserted into the slot, thus permitting the form of the tube to be altered from round to oval.

The second type of tube is for examining the deep-lying parts of the esophagus and the distal parts of the bronchi. These tubes are from 40 to 45 cm. in length and are so constructed that they are able to pass freely through tubes of the first-mentioned type. The small handle-like projection at the proximal end must pass freely through the slot, so as to permit the withdrawal of the external tube. It is preferable for such tubes to have a light carrier for distal illumination. Tubes of the Chevalier Jackson type can be used, but they must first of all be suitably

adapted. In order that a tube of this type may be passed through the basic tube and that the latter may be withdrawn by means of the slot mechanism, the proximal end must be thinned off and the handle-like projection at that end altered.

In addition to the two types of tube already mentioned, there is a third group, which comes between these two, embracing lengths of from 30 to 35 cm. These tubes are so constructed as to pass freely through the short basic tubes and to allow the latter to be withdrawn. It is preferable but not absolutely necessary that tubes of this type be fitted with the slot and shutter mechanism, by which the diameter can be regulated.

Thus, a complete set of tubes includes those of various lengths—23 to 25, 30, 35, 40 and 45 cm.—of which the shorter are fitted with the slot and shutter mechanism. For more everyday use, a basic tube of 25 cm. and another of 40 cm. length are sufficient.

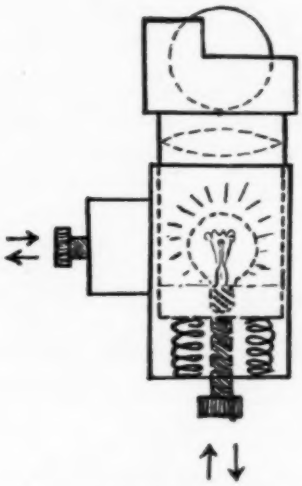

Fig. 3.—Schematic drawing of the illuminating apparatus for proximal lighting.

*Illuminating Apparatus for Proximal Lighting.*—Two screws permit movement of the illuminating apparatus both laterally and vertically, so that all positions can be attained (fig. 3). A square aperture for the examination and manipulation of instruments is situated on the upper right, which position is the most convenient for a right-handed operator. Figure 4 illustrates the adjustments made in order to give intensity of illumination and to insure at the same time an enlarged field of vision. By the use of the graduated tubes it is possible to obtain adequate light projection and opening for inspection. An oval mirror is also convenient for use with oval tubes (fig. 4 *D*). An easy method of focusing the light is provided; by a simple turn of both the screws which set the position of the lamp shaft to the tube, the entire illuminating portion of the apparatus may immediately be fixed in the desired position. The optical box is pivoted on a spring and finger piece, by means of which it can be instantly raised out of the way of the mouth of the tube and out of the line of vision. This is done by simple pressure on the top of the optical box or the finger holder, without altering the position of the tube. When the pressure is removed, the illuminating apparatus immediately springs back into its original position.

*Instruments for Distal Lighting.*—A special instrument has been constructed to adapt distal lighting to tubes with proximal lighting (fig. 5). This is a small contrivance with a spring for holding a lamp and its carrier in place. It can be inserted or withdrawn, so that esophagoscopic procedure can be carried on uninterruptedly (fig. 6 *A*). This same holder can also be used for the aspiratory tube. A special tube has been designed, which can be used for lighting and aspiration

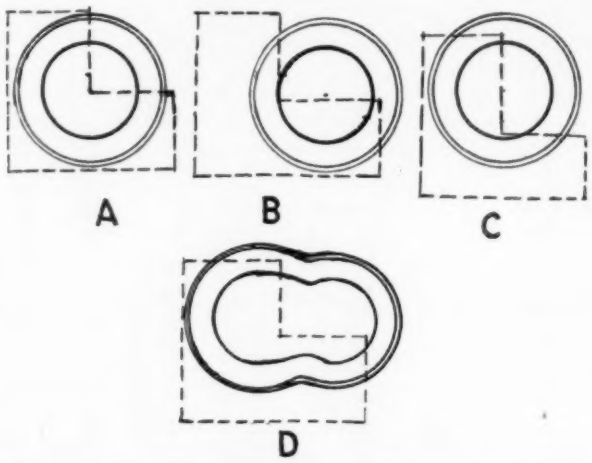


Fig. 4.—The various positions of the illuminating apparatus in relation to the tube: *A*, full light projection; *B*, light projection at the lower half of the tube; *C*, light projection at the left side of the tube and *D*, light projection for the oval tube.

Fig. 5.—Holder for a light carrier.

at the same time (fig. 6 *B* and *C*). These instruments, adapted to the broncho-esophagoscope of Killian, Bruenings,[7] Haslinger [2] and others, have been very useful in practice, and thus they give the best proof of the value of distal lighting.

The holder for the light carrier is attached by a clip to the proximal end of the tube, where it is held fast by the action of a spring. The light carrier is introduced through a small vent and is passed to the distal end of the tube, where it is kept firm by pressure against the wall of the tube. The length of the light

carrier used depends on the length of the tube in use at the time. The holder can also be used with instruments having extending tubes (fig. 6 *A* and *B*) and when it is not desired to make a special channel for the light carrier.

## OPERATIVE TECHNIC

The use of the instruments permits a wide range of choice to the operator, according to the requirements in the individual case, but the operative technic is more complicated than in other methods of bronchoesophagoscopic procedure, in which only one type of illumination is employed and it is unnecessary to resort to a widening of the lumen of the tube (e. g. Denker and Bruenings,[7] Haslinger,[2] Jackson and Jackson[1]). Considering the many different uses to which the instrument can be put, it is possible only to set forth in short the technic of its use.

Before proceeding to examine a subject, the laryngologist must consider the case on its merits and must lay the necessary instruments out within easy reach.

The operative procedure is carried out in the following manner: A short tube with a slot shutter is selected and is attached to the illuminating apparatus for

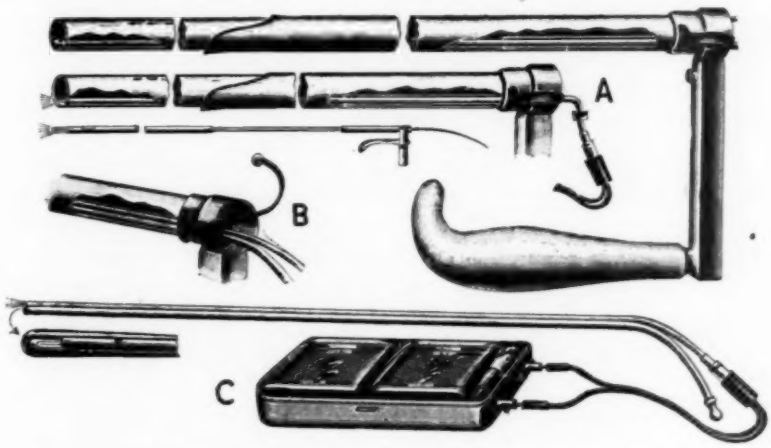


Fig. 6.—*A*, adaption of a tube for distal lighting. *B*, adaption of a tube for lighting and aspiration at the same time. *C*, the tube for lighting and aspiration.

proximal lightning, so set as to give maximum light. The bronchoesophagoscope is then introduced; generally the projection of penetrating and powerful light rays makes possible the orientation and identification of the place to be examined or operated on. If this spot is located deeper than the length of the instrument, a longer tube must be inserted and the short one withdrawn. This action is carried out in the following manner:

1. A longer tube is inserted.

2. The shutter is withdrawn, thus opening the slot (fig. 7 *A*).

3. The inner tube is turned so that the small handle-like projection at its proximal end slides into the slot (fig. 7 *B*).

4. The first, or external, tube is then withdrawn.

For the illumination of the second, or longer, tube, combined lighting may also be employed, but the longer the tube, the more useful is distal lighting.

The manipulation for increasing the working lumen of the tubes is as follows: After a tube of the appropriate length has been introduced, (1) the shutter is

withdrawn, thus opening the slot and (2) another shutter that will increase the diameter of the tube is inserted. If the size of the tube now appears to be insufficient, the whole procedure can be repeated by inserting another shutter that will increase the caliber of the tube still more.

## SUMMARY

The new instrument and new method for bronchoesophagoscopic procedure offered by me aim to permit easy and accurate exchange of tubes during examination, thus avoiding the necessity of reintroducing the bronchoesophagoscope; in addition, the diameter of the tube can be increased in a simple manner.

The instrument is adapted to the use of proximodistal illumination.

For proximal lighting, this new instrument is so constructed as to permit easy regulation of light intensity and is capable of taking tubes of various sizes and shapes.

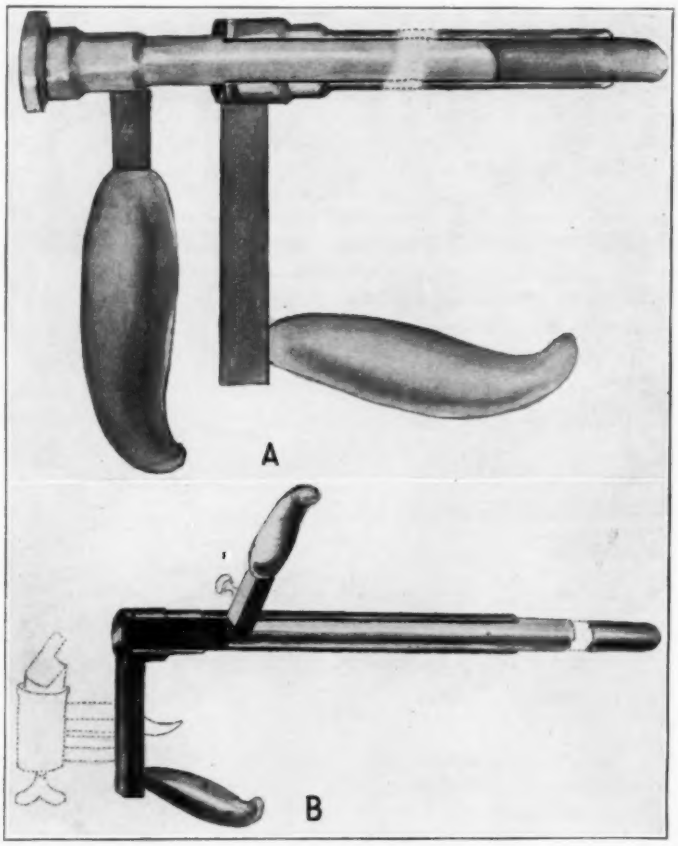


Fig. 7.—*A*, a longer tube is inserted, and the shutter is withdrawn. *B*, the method of passing the longer tube through the basic one (the inner tube is turned so that the small handle-like projection at its proximal end slides into the slot).

# Progress in Otolaryngology

## Summaries of the Bibliographic Material Available in the Field of Otolaryngology

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## TUBERCULOSIS OF THE UPPER RESPIRATORY TRACT

### REVIEW OF THE LITERATURE OF THE PAST TWO YEARS

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Probably the most interesting articles on laryngeal tuberculosis that have been published during the last two years are reports of studies on the manner of invasion of the larynx and of detailed investigations of tuberculous pathologic changes that are peculiar to the larynx. Concerning the first of these subjects, there is general agreement that hematogenous infection of the larynx is possible, but its relative frequency is still a matter of dispute.

In miliary tuberculosis the larynx may be involved as well as other organs, but the rarity of primary involvement of the larynx argues against the common occurrence of an infection of hematogenous origin. Some authors, however, find it hard to explain laryngeal involvement in patients whose sputum is free from tubercle bacilli, and some state further that when the larynx of a patient with a generalized pulmonary lesion shows diffuse involvement of the arytenoids, epiglottis and other areas near the orifice without especial localization the condition in the larynx is the result of a hematogenous infection.

Myerson,[1] who has had extensive experience not only with the clinical but also with the pathologic aspects of laryngeal tuberculosis, reported a study and analysis of 1,000 successive cases. He divided the pathologic changes into three main groups: (*a*) exudative, (*b*) productive and (*c*) destructive. Both the exudative and the productive processes may be manifest as an infiltration, while the destructive gives rise to various proliferative changes.

As to the invasion of the larynx, he expressed the belief that it is probably due to an allergic sensitization at the time of the primary infection and "is very likely produced by generalization of tubercle bacilli

1. Myerson, M. C.: Some Phases of Tuberculosis of the Larynx, Tr. Am. Laryng. A. **61**:172-208, 1939.

in the blood stream with localization in the larynx." He said that the earliest evidence of tuberculosis of the larynx is hyperemia, diffuse and intense. It may be localized to one or may be present in all of the structures. Myerson admitted, however, that in many instances the hyperemia disappears and the larynx does not become involved in what is recognized as a tuberculous process.

His description of the clinical appearances and of the histologic changes is detailed, and in this brief synopsis only some of the more interesting observations can be touched on.

He directed attention to the vascular changes and said that in long-standing and extensive lesions the small arteries may even be obliterated by lymphocytic infiltration and the walls of the larger arteries greatly thickened. There may be thrombosis of the veins, especially the smaller ones, which, he said, are easy to mistake for lymphatic channels. He had never seen any thrombolymphangitis. He expressed the opinion that edema is a more typical allergic reaction than cellular infiltration and that even when the connective tissue cells show degenerative changes a typical tuberculous process may not be present.

He said that ulceration is a fairly frequent result of subepithelial tuberculous infiltration and that the squamous epithelium offers much more resistance than the columnar. The regenerative process is manifest by the various degrees of hyperplasia which occur in the squamous epithelium.

This increase in the epithelial elements may produce a true papillomatous proliferation, which, while not a tuberculous process itself, is superimposed on a subepithelial area of tuberculosis. Myerson directed attention to the possible occurrence of laryngeal polyps which appear clinically benign but histologically show tuberculosis. These must not be confused with the true tuberculoma, of which two types may occur, granulotuberculoma and fibrotuberculoma, the latter, however, being probably a healing stage of the former. Fibrosis is an evidence of healing, Myerson said, and is the end result of every lesion which has the capacity to heal. He expressed the belief that the earliest indication of future healing is a relative increase in the number of epithelioid cells, which may be converted into fibrous tissue.

In acute generalized miliary tuberculosis there may be a massive invasion of the larynx by way of the blood stream. Myerson has seen such an infection develop after the removal of tonsils, which were not known to be tuberculous. While this type of laryngeal tuberculosis is rapidly fatal, he stated the belief that there is another form of miliary spread which is more benign. In this, miliary nodules may be found in only one small area of the larynx and can be recognized clinically by the presence of fine granular nodules which shine through the intact mucosa and are not closely grouped.

He presented a considerable discussion of the symptoms and diagnosis. He expressed the opinion that the laryngeal mirror affords the best information for diagnosis; that roentgen examination is of little value, and that direct laryngoscopic inspection is to be avoided in the great majority of cases, especially in the presence of an acute, active tuberculous lesion.

As to prognosis, he held that the type of lesion is more important than its age. He said that it is not the stage of the lesion or the time of recognition of involvement of the larynx which determines the future course of the disease. A lesion may at a very early stage indicate a serious invasion.

As to a treatment, he stressed the importance of vocal rest and expressed the belief that complete silence is superior to whispering. He has not found that chaulmoogra, cod liver or other oil has any curative effect, though they have a definite value as temporarily soothing and cleansing agents. Of the use of ultraviolet rays he said: "credit for improvement in our cases cannot be attributed to this form of therapy." He discussed in some detail the use of the cautery, which he claimed is the best single weapon available to the laryngologist, but stated that all cutting instruments must be avoided.

He ended his article with an expression of the opinion that the value of local therapy in tuberculosis of the larynx is greatly overestimated, saying that an analysis of the treatment of 145 larynxes which had healed revealed that 87 received no local therapy except silence.

Eschweiler [2] published the results of his clinical observations and histologic examinations during the years 1936 and 1937. He directed attention to the difficulty of recognizing the early localization of the lesion by clinical examination and stated that frequently the subsequent histologic study shows a very different picture. For instance, he found histologically that accumulations of lymphatic tissue are apt to be the first place of infection, though this did not correspond to his clinical observations. He described the different ways in which the disease in the larynx progresses, both in cases in which productive tuberculosis shows a distinct tendency to heal and in those in which the resistance of the patient has been lost and the disease is in an advanced stage and progressing, with perhaps the formation of abscess and fistula. He mentioned particularly the presence both in the tissue and in the lymph spaces of a fibrinous exudate. This exudate in the tissues results as a peripheral reaction to the tuberculous disease. When it is found in the lymph capillaries, it leads to tuberculous lymphangitis. If the resistance of the patient is

2. Eschweiler, H.: Clinical and Histologic Observations and Investigations on the Development of Tuberculosis of the Upper Respiratory and Alimentary Tracts, Ztschr. f. Hals-, Nasen- u. Ohrenh. **43**:163-214, 1938.

low, this exudative tuberculous lymphangitis may go on to the formation of small cold abscesses, but when the immune biologic resistance of the patient has been improved these exudative centers may become organized into the connective tissue. The spread of the disease from the superficial tissue into the deeper structures is almost always by way of the lymph vessels.

One of the most important clinical features of tuberculous lymphangitis is that it leads to chronic edema. This, however, must be distinguished from the acute glasslike edema, which is probably due to toxic involvement of blood vessels, perhaps from a mixed infection. Chronic edema, if untreated, usually persists until it is drained by ulceration, which acts almost like natural scarification. Edema involving the laryngeal orifice may spread down to the ventricular bands and involve the thyroarytenoid muscles, with subsequent atrophy of these muscles. The author has seen cases in which only one muscle was involved. Both clinical and histologic examinations have demonstrated that the region around the laryngeal opening is seldom involved by the spreading upward of the disease from an intrinsic lesion.

Eschweiler stated the belief that when the entrance to the larynx is diffusely involved the infection is hematogenous in origin.

Although the medullary substances of ossified laryngeal cartilages may show miliary metastases, the involvement of true cartilage, according to Eschweiler, occurs only from disease that progresses inward from the mucous membrane. He has noticed that in cases in which there is mild or slight perichondritis or even osteomyelitis clinical symptoms may not be observable and therefore the diagnosis of perichondritis is often difficult. Also he has shown histologically that edema of the arytenoid bodies is not necessarily an indication of perichondritis. He described an arthritic condition of the arytenoid joint that is difficult to diagnose and is analogous to that type of tuberculosis of the larger joints in which rice bodies may be found without clinical disturbances.

Spira,[3] basing his observations on clinical material, stated the belief that a hematogenous infection of the larynx is probable when specific changes occur in the larynx and a lesion of the lung is not demonstrable either by physical or by roentgen examination. Further, the presence of lesions in other portions of the body with either active or healed pulmonary tuberculosis is indicative of a hematogenous origin. The author recognized two types of hematogenous laryngeal tuberculosis. The first is an acute, fulminating process which begins in the region of the laryngeal opening and spreads into the interior of the larynx. This is accompanied by marked odynphagia, which greatly interferes with the

3. Spira, J.: Pathogenesis and Clinical Study of Hematogenic Laryngeal Tuberculosis, Monatschr. f. Ohrenh. **72**:700-711 (July) 1938.

taking of sufficient nourishment. On examination the laryngeal orifice is seen to be acutely swollen and studded with small yellowish nodules, some of which may be ulcerated. At first the lung may show little involvement, but in a short time there develops a rapidly progressing generalized infection. The prognosis is poor, the majority of patients dying very early in the course of the disease. Sometimes there is an apparent temporary recovery, but in a few months or a year or so there is a recurrence after which the disease progresses rapidly.

In the second form of hematogenous laryngeal tuberculosis, Spira said, the lesions most frequently begin on the vocal cords, more rarely on the ventricular bands or the epiglottis. At first they are of an infiltrative nature and later may become ulcerated. This is the benign type and usually heals sooner or later. However, even in this type there may be later disseminations which lead to a fatal outcome.

While he expressed the belief that a hematogenous metastasis may cause lesions in the interior of the larynx as well as around the laryngeal orifice, he said that he did not understand why the orificial lesions are so much more virulent than those of the intrinsic type.

Wessely [4] stated that infection of the larynx by contact can take place only when there are bacilli in the sputum and that such infection is characterized clinically by a small circumscribed beginning, which has a tendency to remain localized unless the general resistance of the patient is lowered; then the lesion extends into the surrounding tissues. The diagnosis of hematogenous infection is suggested by a turban-like infiltration of the epiglottis, infiltration of one or both aryepiglottidean folds and generalized diffuse infiltration of the entire laryngeal interior.

Knapp [5] reported a histologic study of 20 fresh specimens and a number of preserved specimens of the tuberculous larynx. Among all these there were perhaps 3, and surely only 2, which from the histologic observations and the general conditions revealed by autopsy could be said to have had infection of hematogenous origin. He said that a diagnosis of hematogenous infection cannot be made by examination of the larynx alone but that the examination must include other portions of the throat, which should show a hematogenous dissemination of miliary tubercles. He stated that the protective reaction of the epithelium to infiltrating tuberculous granulation tissue is seen only in epithelium of the squamous type, cylindric epithelium being free from proliferative changes.

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4. Wessely, E.: Differential Diagnosis Between Bronchogenous and Hematogenous Laryngeal Tuberculosis, Zentralbl. f. d. ges. Tuberk.-Forsch. **50**:393-401 (June 24) 1939.

5. Knapp, E.: Pathologic Histology of Laryngeal Tuberculosis, with Special Reference to Probable Hematogenic Route of Infection, Hals-, Nasen- u. Ohrenarzt (pt. 1) **29**:303-335 (Sept.) 1938.

As to infection of the mucous glands, he said that the ducts are resistant to tuberculous disease but that the glands themselves frequently show a predilection for this disease. He recognized that tuberculous osteomyelitis may be found in the ossified portions of the laryngeal cartilages and is probably of hematogenous origin. He also mentioned that where the cartilage has become ossified there may develop periostitis but that this does not cause sequestration, as the bony area receives nutrition from the medullary substance.

Randerath [6] prepared an elaborate record of the pathologic anatomy of laryngeal tuberculosis. His work is based on a literary review of 167 references and on his own researches, which consist of macroscopic and microscopic examinations of a fairly large number of tuberculous larynxes. His article is divided into three parts, the first dealing with primary laryngeal tuberculosis, the second with involvement of the larynx in general hematogenous tuberculosis and the third with what he terms chronic laryngeal tuberculosis.

In regard to primary laryngeal tuberculosis, he said that there have been scarcely any cases which scientific investigation has proved to be instances of this type of laryngeal disease.

In dealing with the involvement of the larynx in general hematogenous tuberculosis, he spoke first of the changes of the larynx found in acute miliary tuberculosis, concerning which he could find no literary references. However, he himself reported examination of the larynx in 9 cases in which there was characteristic early generalization. In 4 of the cases he found ulcerated laryngeal lesions, but in each of these cases there was either a primary cavity in the lung or an advanced confluence of the pulmonary lesion, and he concluded that in these 4 cases the laryngeal lesion was due to infection by contact. In a case in which there was no ulcerative lesion of the larynx, he found a single tubercle in the musculature. Of 8 cases in which generalization had occurred late in the course of the disease, there was no tuberculous change of the larynx in 5. In the other 3 a few miliary tubercles were found. In 1 of these 3 a subepithelial tubercle was found in the region of the lymph nodes of the ventricle; in 2, in which there was partial ossification of the laryngeal cartilages, miliary tubercles were found in the myeloid tissue of the ossified cartilages. So, of the 17 cases of general hematogenous, i. e., miliary, tuberculosis, the larynx was free in 13. In only 1 of the 4 cases in which there was laryngeal involvement was the tubercle in the subepithelial tissue; in the other 3 the mucous membrane was normal. In 1 of these 3 there was a tubercle in the muscle, and in the other 2, tubercles were found in ossified laryngeal cartilages.

6. Randerath, E.: Pathologic Anatomy of Laryngeal Tuberculosis, Ergebn. d. ges. Tuberk.-Forsch. **9**:143-190, 1939.

Randerath further examined the larynxes of 21 patients with advanced hematogenous infection developing from chronic extralaryngeal tuberculosis. In none of the larynxes was there any macroscopic evidence of tuberculous involvement. In 1 specimen the histologic examination showed beginning chronic tuberculosis. In 12 of the remaining 20 specimens there were no evidences of tuberculosis, but in 8 the histologic examination showed miliary tubercles, evidently of hematogenous origin. In 6 the tubercles were in the ossified laryngeal cartilages, and in 3 they were in the subepithelial tissue in the neighborhood of lymph nodes. In 2 others the subepithelial tubercles were found in lymph nodes without any other laryngeal involvement, and the laryngeal cartilage in these larynxes showed no ossification.

To recapitulate these rather important findings, the author has shown that hematogenous tubercles may occur in the larynx in cases of acute general miliary tuberculosis or in cases in which the condition is chronic, with a hematogenous dissemination. The tubercles are most frequently found in the myeloid tissue of ossified laryngeal cartilages and in the subepithelial lymph nodes. While they were found in the bone marrow, they were not found in the cartilage of the larynx unless ossification had taken place.

Randerath asserted his belief that these miliary tubercles in the bone marrow do not have any tendency to produce chronic extensive laryngeal tuberculosis.

Not only from his own observations but also from the literature of other observers, he stressed the point that the lymphatic tissues of the larynx, and especially that type in which there is a circumscribed formation with follicles, have an important part in the development of laryngeal tuberculosis.

In his chapter on chronic tuberculosis, he has made an exhaustive review of the literature concerned with the manner of infection of the larynx. He said that there are three modes which have been widely discussed: first, infection of the mucous membrane of the larynx by direct contact, second, hematogenous and, third, lymphatic. After careful consideration of the views expressed by the various investigators and clinical writers, he said that the large majority of authors have come to the conclusion that as far as chronic laryngeal tuberculosis is concerned the only manner of infection which has been proved is contact, and his own experience is confirmative of this view. He stated the belief that a diagnosis of hematogenous infection can be made only when there are miliary tubercles and that from the results of his researches concerning the frequency and localization of these hematogenous tubercles it does not seem likely that they have any practical significance in the origin of chronic laryngeal tubreculosis. The best

that can be said for the theory that such infection is hematogenous is that it is theoretically possible. He expressed the belief that chronic tuberculosis of the larynx is never of lymphatic origin.

As to the invasion of the larynx by the bacilli through contact, he quoted and agreed with Manassa. It may occur, first, through intact epithelium, second, through small epithelial defects and, third, by way of the ducts of the mucous glands. He said that where there is ciliated epithelium, tubercles may be found between the epithelial cells accumulating in the submucosa, while, on the other hand, where there is squamous epithelium the bacilli do not penetrate unless the surface has been broken. Simple catarrhal conditions or mechanical injury to the mucosa undoubtedly favors the entrance of the bacilli.

Randerath asserted that in the large majority of cases of laryngeal tuberculosis the changes cannot be divided into exudative and productive types, as both are usually found together. Rather, if any division is to be made, he expressed agreement with Beitzke and Huebschmann, who divided them into ulcerative and infiltrative types.

In chronic laryngeal tuberculosis the infiltrative lesion is characterized macroscopically by more or less thickening of the laryngeal wall. In cases in which the disease is advanced, histologic examination shows that the entire tissue between the epithelium and the cartilage is filled with closely packed productive tubercles, though the epithelium covering this area may be entirely intact even in the presence of extensive lesions. However, in some cases there may be sharply outlined areas of thickened superficial epithelium, or the epithelium may be destroyed in small areas or over a considerable extent. In the early stages, when the infiltration is not extensive, the tubercles are found only in the superficial layers of the subepithelial tissue. Between the tubercles there is more or less lymphocytic infiltration. The tubercles themselves may be purely productive in character or may have central areas of greater or less caseation. Randerath asserted that he had seldom seen the edema described by Manassa in cases of infiltrative laryngeal tuberculosis and did not believe that it plays an important part in the thickening of the laryngeal wall. While it is possible for a purely productive lesion to exist without evidence of caseation, infiltration as a rule should be considered simply as evidence of an early stage of the disease.

In his chapter on chronic ulcerative laryngeal tuberculosis, Randerath made several interesting observations. He verified the finding of Manassa that ulceration is frequently due to an infiltration of the epithelium by the underlying tuberculous granulation tissue. When ulceration is a primary condition, there are present a large number of polymorphonuclear leukocytes, which give the impression of a nonspecific abscess. As a result of this infection, the epithelium is destroyed and

loosened. Such abscesses, although nonspecific in origin, may show the presence of tubercle bacilli, for they act as gateways through which the bacilli can gain access to the underlying tissues. Sometimes a zone of nonspecific granulation tissue may surround the tuberculous area, which in time throws off the disease. This border of nonspecific granulation tissue is marked in older cases, yet it must be recognized that the ulceration may be surrounded by typical tuberculous granulation tissue with the presence of giant cells. Tuberculous ulceration may either spread along the surface or penetrate into the deeper tissues, with undermining of the edges of the ulceration.

Randerath found that the extension of tuberculous infection through the lymphatics, as described first by Manassa, in 1889, and later by Eschweiler, in 1938, occurs more frequently in the ulcerative type of the disease than in the purely infiltrative. He expressed agreement with Eschweiler that chronic edema in the region of the arytenoids is probably due to blockage of the lymphatics. He described two types. One is a collateral perifocal inflammatory edema in the region of the specific disease, which is frequently acute and is changeable. The second, a chronic edema, is the result of the tuberculous lymphangitis.

Tuberculous perichondritis of the larynx results from a spreading inward of the ulcerative condition of the mucous membrane. Randerath stated that he did not believe that the hematogenous tubercles sometimes found in the ossified areas of the laryngeal cartilages or in the lymphatic centers ever give rise to perichondritis. The perichondrium becomes involved by a progression of the disease from the laryngeal mucosa. The periostitis may be the result either of a simple pyogenic infection or of the natural extension of the tuberculous disease. When it is a nonspecific infection, the cartilage itself may be infiltrated with polymorphonuclear leukocytes, with resulting necrosis of the cartilage and sequestration. This sequestration may involve the ossified areas of the cartilage as well as the cartilage itself. True tuberculous osteomyelitis is the result of direct extension of the mucosal disease, not of the hematogenous tuberculosis sometimes found here.

Concerning invasion through the mucous glands, Randerath asserted that he had never seen tuberculous changes in the region of the mucous glands unless the disease existed in other parts of the larynx.

It has long been recognized that tuberculosis may produce tumor-like growths in the larynx and that many of these are due to localized accumulation of tuberculous granulation tissue. Randerath said that there is a type of papillomatous tumor occurring in the interarytenoid region, which is found in patients with laryngeal tuberculosis when biopsy has failed to show any tuberculous disease. These growths, however, usually have an extensive underlying lesion.

Another important article on the pathology of laryngeal tuberculosis is one by Blomroos.[7] This is an elaborate study of tuberculous larynxes removed at autopsy from 18 persons with extensive tuberculous processes of different kinds. It is impossible to make a short summary of this work on account of the enormous amount of detail which the author recorded, and it would be advisable for any one especially interested in this problem to read the article in the original. However, he has advanced a few interesting theories that are worth attention here.

He said that when there is a high grade immunity to the tuberculous toxin the body will show a strong reaction and that when the larynx is involved this is made manifest by a productive type of lesion giving rise to increase in the connective tissue elements and the presence of more or less fibrotic tuberculomas and papillomatous changes. However, when the general resistance is lessened, so that there is anergy, an exudative form of disease is manifest with extensive destructive lesions. If the resistance of the organism can be built up in cases of the latter form of infection, the exudative process rapidly recedes and is replaced by a productive type of lesion, with the formation of granulation tissue and an increase in the connective tissue elements. Blomroos said that of the areas of predilection for early deposits of tubercle bacilli the posterior commissure is first, then probably the arytenoids, close to the latter the ventricles and then the anterior portion of the vocal cords.

He recalled the fact that in the fetus the interior of the larynx is covered with cylindric epithelium, the edges of the vocal cords being the only areas showing squamous epithelium, but during the early months of life the squamous epithelium increases until it is found in the interarytenoid region, the aryepiglottic folds, the laryngeal surface of the arytenoids and on both sides of the vocal cords. However, squamous epithelium can be greatly extended by any form of irritation. Therefore, in cases of severe laryngeal tuberculosis, as the result of constant cough or other irritation cylindric epithelium may be found only in the ventricles and even here squamous epithelium can be seen along the edges of ulceration and in some cases without ulceration. Subepithelial lesions may give rise to pachyderma, which is seen most extensively in the posterior commissure, where it may even become papillomatous in character. Again, the growth of the epithelium may be inward, producing branching prolongations into the underlying tissue, and sometimes these prolongations may be cut off, so that nests of epithelial cells are found deep in the tuberculous areas.

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7. Blomroos, T.: Pathologic-Anatomic Studies of Laryngeal Tuberculosis, Acta oto-laryng., 1939, supp. 28, pp. 1-159.

Blomroos did not find any evidence to indicate that mucous glands can be considered as an area of predilection for tuberculous deposits, and in only 1 case of early involvement were tubercles found in the region of the ducts.

He directed attention to the importance of small traumas as a likely source of infection with tubercle bacilli.

He asserted that perichondritis and chondritis are more apt to involve the arytenoids than other cartilages of the larynx and that the cartilage as well as the perichondrium may be invaded by the tuberculous granulation tissue.

It would be perhaps worth while to quote the author's summary in full, as it gives his approach to the subject as well as his own ideas concerning the results of his study:

Although laryngeal tuberculosis has been the subject of extensive and thorough studies, there are still several presumptions which are not yet fully confirmed and many problems which are not completely solved. Among these are the following:

a. The comparison between the clinical and the pathoanatomic picture of laryngeal tuberculosis.

b. The ulcerative processes and their origin.

c. The classification of laryngeal tuberculosis.

d. The comparison between the different types of pulmonary and laryngeal tuberculosis.

e. The way in which tuberculosis spreads to the larynx.

f. The main lines of therapeutic measures for the different types of laryngeal tuberculosis.

g. Secondary phenomena in laryngeal tuberculosis.

The material was therefore studied with reference to these problems and the following conclusions drawn:

The picture of the spread of laryngeal tuberculosis obtained by indirect mirror examination forms only a small part of its actual extent, and this is particularly true as regards cases of a destructive nature, in which processes that deeply penetrate the tissues may always be expected. The significance of this fact for active surgical treatment of laryngeal tuberculosis is quite obvious, considering what an infinitesimal part of the actual tuberculous processes we are able to treat in this way.

The largest ulcerative processes are always to be found in those parts of the larynx most exposed to mechanical lesions; consequently, now more than hitherto, attention should be paid, e. g., to such mechanical irritation as is caused by coughing and talking. The origin of tuberculous ulcerations is not uniform, and at least the following methods of formation must be considered possible:

1. By lesions due to mechanical irritants; 2. by decomposition of the subepithelial tubercle, whereby the epithelium is involved in the necrosis; 3. by the pressure necrosis to which the epithelium is subjected by the growing subepithelial tubercle; 4. by the toxicoinflammatory effect on the epithelium of the lymphocytes surrounding the tubercle; 5. by the secondary infection by tubercle bacilli of epithelial defects evoked by general inflammation.

A complete classification of laryngeal tuberculosis must include, besides the purely morphologic grouping into infiltration, ulceration, perichondritis and chondritis, tuberculomas and papillomas, information on the productive or exudative nature of the process, and this is of great importance for prognosis as well as therapy.

As regards the congruency of laryngeal and pulmonary tuberculosis, it is on the whole fairly complete, at any rate in cases of a more pronounced, either productive or exudative, character. Periodic incongruity is due to temporary changes in the local state of immunity, but these changes are scarcely of a persistent nature.

As to the theories of the different ways in which the tuberculosis may spread into the larynx, an infection via the blood vessels may be considered possible at the generalization stage. That type of laryngeal tuberculosis by which we are most frequently confronted is undoubtedly the sequential disease of an isolated pulmonary phthisis arising in the tertiary stage, and here contagious (contact) infection is the most common.

For the therapy it must always be remembered that the general character of the tuberculosis in question and the general as well as the local state of immunity of the body are of greater importance than the local findings. Active treatment of the local process is, first, hopeless in unfavorable cases, considering the real spread of laryngeal tuberculosis, and, second, fatal if we consider the inability of the organism to overcome the resulting general as well as local reactions.

The glandular tissues have no predilection for the localization of laryngeal tuberculosis. The changes, both inflammatory and degenerative, occurring in the glandular tissues are of a secondary nature. This is also true of the muscles and the epithelium.

The article on laryngeal tuberculosis by Rickmann [8] is an elaborate treatise consisting of an extensive review of the literature and a report of the author's own clinical observations.

Needless to say, the greater part of this article is a restatement of facts that are today well recognized by laryngologists, but for the student especially interested in the subject of laryngeal tuberculosis it provides a comprehensive and interesting survey of the whole subject. It certainly covers every possible aspect of the clinical picture, and its criticisms and summaries are not radical or eccentric but fair-minded and reasonable. Although it is impossible to write a synopsis of all the material covered by Rickmann in this article, a few of his ideas are original and worth attention here.

For instance, in speaking of the disturbance of sensibility in the larynx, he said that it is not necessary to conceive that pain is evidence of an advanced tuberculous condition, as it is often found in the early stages of the disease, when the condition can be scarcely recognized by laryngoscopic examination. He expressed the belief that the pain in the early stages is probably due to changes in the circulation of the blood which nourishes the sensory nerves, these changes producing hyper-

8. Rickmann, L.: Laryngeal Tuberculosis: Clinical Aspect, Ergebn. d. ges. Tuberk.-Forsch. **9**:191-250, 1939.

sensitivity. However, he recognized that the most common cause of odynphagia is ulceration around the laryngeal orifice, while the greatest discomfort is usually associated with perichondritis.

In another place he directed particular attention to the importance of roentgen findings as an aid in diagnosis, mentioning, as did Thost previously, that decalcification of the laryngeal cartilage is evidence of tuberculous disease. He also said that swellings of the mucous membrane are easily recognized in roentgenograms, as the lumen of the larynx is usually filled with air. Even minute changes due to thickening of the mucous membrane can be easily detected, and this is especially important in making a diagnosis of early lesions in the ventricle. He stressed the importance of taking an anteroposterior picture in order to determine which side of the larynx is involved. He said that syphilis probably offers the greatest difficulty in differential diagnosis, as tertiary lesions show so many and such varied pathologic pictures and even the histologic picture of syphilis may closely resemble that of tuberculosis. He cited a case from Berendes, in which typical giant cells cleared up under antisyphilitic treatment.

Under the head of treatment he stressed the importance of the hygienic and general care of patients with laryngeal tuberculosis even when there is insignificant involvement of the lungs and stated the belief that artificial pneumothorax is an important therapeutic agent. While admitting that there is no doubt that rest of the voice is an important factor, Rickmann did not express agreement with Simin that either resection of the recurrent laryngeal nerve or the injection of alcohol into it is often advisable. Likewise, he asserted that tracheotomy is capable of more harmful than good effects on the larynx and should be done only in those cases in which stenosis is present.

As a local medicament he used a 5 to 10 per cent solution of menthol in a vegetable oil, sprayed directly into the interior of the larynx. The use of liquid petrolatum should be avoided on account of the possibility of damage to the lung.

He had carefully reviewed the literature on the use of gold compounds in the treatment of tuberculosis, especially with respect to the cases in which the larynx was involved. He said that gold has no bactericidal action on the bacilli but that it is apparently stored up for a long time in the connective tissue and the reticuloendothelial structure. It may be found in the tuberculous centers and in the epithelioid cells many months after the last injection, and around this area of gold accumulative calcareous deposits were noticed to be more extensive and to occur earlier than is usual in untreated tuberculosis. This increase in the calcareous deposit, which seems to be due to the presence of the gold, is further stimulated by local roentgen therapy, and therefore the

combination of injections of gold compounds with roentgen treatment may have very favorable results.

He said that galvanocauterization today occupies the first place in the surgical treatment of laryngeal tuberculosis, while "bloody procedures" are now seldom used. Tuberculous infiltrations should be treated by ignipuncture, ulcers should be seared by means of a flattened blade and tuberculous tumors should be radically burned out. Of the agents for radiation, roentgen rays give the best and surest results, and as a therapeutic measure roentgen irradiation occupies an outstanding position. It is easy on the patient and can be used on those who are ambulatory. The best results undoubtedly will be obtained by combining the use of the cautery with roentgen radiation.

From his own experience in cases of pregnancy in which there was laryngeal tuberculosis he recommended the following indications for the interruption of the pregnancy: 1. It should be done without hesitation in all cases of widespread productive laryngeal tuberculosis which offers no prospect of healing. 2. When there is a latent and stationary infiltrated lesion, especially in the region of the vocal cords and posterior wall, it is not absolutely necessary to interrupt the pregnancy immediately, but the patient must be under constant medical supervision. 3. When there is progressive laryngeal tuberculosis which does not give evidence of healing or improvement, pregnancy should be terminated within the first three months.

Rubin and Galburt [9] stated that relatively few tuberculous children are referred by the pediatricians for a laryngeal examination, for the early local symptoms are mild and are overshadowed by the patient's constitutional condition. They performed indirect laryngeal examinations on 100 tuberculous children, and a large number of lesions were found. Hyperemia and infiltration were the conditions most commonly observed, and these were seen most frequently in the posterior commissure. The greatest percentage of children with laryngeal involvement was found in the group with caseous pneumonic tuberculosis. Of 54 children in this group, 23 were found not to have tubercle bacilli in their sputum, gastric contents and feces; in the other 46, with tubercle bacilli in the sputum, gastric contents and feces, there were only 21 normal larynxes. The authors expressed the belief that the larynx becomes infected in order of frequency as follows: (*a*) by way of the lymphatics from the primary pulmonary lesion, (*b*) by direct contact with bacilli-laden sputum, (*c*) by the blood stream, as in miliary infections, and (*d*) by direct extension from a primary pharyngeal lesion. The symptoms, if any, are mild, and they may vary from slight huski-

9. Rubin, H., and Galburt, S.: The Larynx of the Tuberculous Child, Arch. Otolaryng. **30**:421-428 (Sept.) 1939.

ness to complete aphonia, with only occasionally sore throat or slight dysphagia. "None of the severe symptoms usually seen in the adult larynx were found."

The authors advised bronchoscopic examination of tuberculous children whose sputum fails to show tubercle bacilli, because a direct smear will often show the presence of the bacilli. Bronchoscopic examination is contraindicated when active laryngeal lesions exist.

The chief therapeutic measures are vocal rest and the application of the galvanocautery, though the general and pulmonary condition must be properly handled. Collapse therapy improves not only the local condition but also the general prognosis.

During the past two years not many if any new methods of local treatment have been added to our therapeutic armamentarium, but clinical experience has confirmed the value of some technics and discredited others, while some unproved methods are still in what might be termed the experimental stage.

The use of solid carbon dioxide (dry ice) has been revived by Bosche.[10] He claimed that solid carbon dioxide is painless if used in connection with local anesthesia and that after its application patients with marked dysphagia were able to eat normally within seventeen to eighteen and a half hours. This sedative action was said to last from seven to nine days. The author noticed distinct reduction in the swelling, and if there had been some stenosis, free breathing usually followed the treatment. He looked on solid carbon dioxide, however, not as a curative agent but as a palliative one.

Dierichs[11] had for two years tried out galvanization of the tuberculous larynx for the relief of pain according to the method of Grain. He encountered some complications, such as burning of the skin and glottic cramp, which caused him to modify the technic; the modification, though slightly decreasing the efficiency, made the treatment absolutely harmless. The electrodes he used were thinner, so that they fitted more easily into the curvature of the patient's neck, and were held in place by adhesive straps. The electrical dosage was regulated rather by the patient's sensations than by a milliamperemeter. The strength of the current was gradually raised until the patient felt a "fine prickling." This was followed by a sense of constriction, and occasionally there was salivation and a metallic taste. The duration of the first sitting was only twenty to thirty minutes, but the time was increased to one hour in subsequent treatments. While the functional results were rather sur-

10. Bosche, C.: Therapy of Laryngeal Tuberculosis with Carbon-Dioxide Snow, Rev. de laryng. **60**:776 (Nov.) 1939.

11. Dierichs: Galvanization in Painful Laryngeal Tuberculosis, Deutsches Tuberk.-Bl. **12**:191-193 (Aug.) 1938.

prising in that the patient could eat again and was practically free from pain, the author did not consider that the treatments were in any way curative.

Cotton-Cornwall [12] has also used ionization, or electrical anesthesia, which he claimed is the best method for relief of pain. He said that it is simple and without danger if ordinary care is taken and completely effective in most cases. He used a 45 volt dry battery equipped with a current controller made of a reducing coil and with a milliamperemeter. He covered the electrode with lint at least ⅓ inch (0.85 cm.) thick, and the negative pole was wet with a 2 per cent solution of potassium iodide. The lint on the positive pole was moistened with pure water. He began his treatment with 4 to 5 milliamperes, which was gradually increased, but except in rare cases he never went above 9 milliamperes. The applications were made daily for one-half hour until the resulting anesthesia lasted for at least twenty-four hours. After this, the applications were given only when there was a recurrence of pain.

Kriegsmann [13] stated the belief that careful and prolonged fractional roentgen treatment in laryngeal tuberculosis is not only beneficial in that it causes marked lessening of the pain but that it has a distinctly favorable effect on the pulmonary lesion as well. This is probably due to the improved general nutrition. He said that he had had no bad results when the doses remained small, according to his recommendations, and he asserted that if the dosage he described is followed out roentgen radiation is available for all types of lesions, both productive and exudative.

In 1937 Banyai published his observations on the use of cod liver oil in the treatment of localized tuberculosis. At that time he had treated 47 patients, 25 of whom had laryngeal involvement. His later report [14] covers 91 cases of laryngeal tuberculosis and 6 of pharyngeal tuberculosis. He stated that cod liver oil can be used with absolute safety in tuberculous pharyngitis and laryngitis, and he has seen no evidence of any pulmonary irritation. The ulcerative lesions showed rapid epithelization and healing, and there was a favorable therapeutic response even in cases of localized infiltration and vegetative granulation. However, laryngeal tuberculosis with marked edema was rather resistant to the treatment.

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12. Cotton-Cornwall, V.: Relief of Pain in Laryngeal Tuberculosis, Lancet **2**:1109-1110 (Nov. 12) 1939.

13. Kriegsmann, G.: Prolonged Roentgenotherapy for Relief of Pain in Laryngeal Tuberculosis, Hals-, Nasen- u. Ohrenarzt (pt. 1) **30**:121-123 (March) 1939.

14. Banyai, A. L.: Cod Liver Oil for the Local Treatment of Tuberculous Pharyngitis and Laryngitis, Arch. Otolaryng. **27**:154-160 (Feb.) 1938.

His technic consisted of spraying the larynx three times a day with cod liver oil by means of an ordinary atomizer. The applications were always given after meals to avoid possible anorexia caused by the taste of the oil, and the oil was warmed prior to application. An instructed nurse or attendant held the tip of the atomizer, directed downward, just beyond the roof of the tongue without touching the pharyngeal structures, while the patient held the tongue forward between the thumb and the index finger. Probably from ten to twelve compressions of the bulb of the atomizer delivered a sufficient amount of the oil into all the accessible parts of the larynx. In a few cases the treatment was interrupted because of nausea and vomiting, probably due to the taste of the drug, so that recently he has been adding a 1 per cent solution of menthol and camphor to the cod liver oil.

Chiray and Mollard [15] have proposed a rather unique procedure for the control of the pain and edema that accompany laryngeal tuberculosis. In their article they spoke of advanced lesions of the larynx, especially those with edema which prevents the patient from swallowing or even phonating. They expressed the belief that the edema is a vasomotor phenomenon due to the pathologic-anatomic changes rather than the result of inflammation per se. They had found that injections of alcohol into the superior laryngeal nerve were not always satisfactory. They then attempted the infiltration of the sympathetic ganglion, following the method of Leriche. In the first case they blocked the stellate ganglion and gave the patient almost complete relief from pain as well as from the edema. However, with a second patient injection into the stellate ganglion alone was not successful, but two days later they anesthetized also the first three dorsal sympathetic ganglions and again gave the patient marked relief from the pain and reduction of the congestion. Similar results were obtained in the treatment of 12 other patients.

From these experiences the authors concluded that infiltration of the stellate and upper sympathetic thoracic ganglions in advanced tuberculosis of the larynx with edema reduces the edema and relieves the dysphagia. They did not claim any curative action except that the relief of pain and edema enables the patient to obtain proper nourishment, so that he may survive a sufficient length of time for spontaneous recovery to occur.

As far as I know, this blocking of the sympathetic system for the relief of edema and pain in laryngeal tuberculosis is an original suggestion. A priori one would argue that removing the constricting action of the blood vessels would have a tendency to increase the edema rather than to relieve it, but recent advances in the treatment of phlebitis of

15. Chiray, M., and Mollard, H.: Cocaine Infiltration of Stellate and Thoracic Ganglions in Therapy of Edematous Tuberculous Laryngitis, Ann. d'oto-laryng., May 1939, pp. 464-466.

the lower extremities by injections of procaine hydrochloride into the lumbar sympathetic ganglions have shown that the swelling and pain in this disease may be entirely relieved by such sympathetic blockage. The mechanics which produce such a clinical result are still not quite understood, though it is probable that the dilatation of the venous channels tends to drain the congested area and it may be that a part at least of the pain in inflammatory lesions is due to hypersensitive blood vessels which receive their sensation impulses from the sympathetic system; therefore, pain may be relieved. Further, in proper hands the injection of the upper thoracic ganglions is not a difficult or dangerous undertaking, so that further trial of this method is not only a justifiable but probably an indicated clinical procedure in cases of advanced, hopeless laryngeal tuberculosis.

Woodward [16] directed attention to the importance of collapse therapy in the care of patients with laryngeal tuberculosis. He had two groups of patients, in both of which the local surgical treatment consisted chiefly of galvanocauterization. In the first group there were 136 patients, treated between 1923 and 1928, and in the other group there were 152, treated between 1933 and 1938. In the first group collapse therapy was used for only 4.4 per cent, while in the second group it was used for 49.3 per cent. He stated that there was a gain of 8.5 per cent in number showing improvement at discharge, solely as the result of the addition of collapse therapy.

He stated the belief that cauterization is by far the most important and valuable of the surgical procedures in the treatment of laryngeal tuberculosis. "Bloody removal" of a tuberculoma is justifiable, but the base of the wound should always be cauterized. The same precaution applies to the removal of material for biopsy. The removal of the epiglottis often gives satisfactory results. He asserted that blocking of the superior laryngeal nerve is not frequently necessary since the use of the cautery and especially of collapse therapy. Tracheotomy should never be done except for the relief of stenosis.

The importance of tuberculous deposits in the tonsillar tissues has received considerable attention during the past two years, and, while some addition has been made to statistical data, it is remarkable that many of the authors were apparently unconscious of the experimental and clinical work that had been done during previous years. Alpert [17] examined the tonsils from 172 children with extrapulmonary tuberculous lesions and 30 with probable pulmonary disease. Of the 172 children with extrapulmonary involvement, 15 had tubercle bacilli in

16. Woodward, F. D.: Laryngeal Tuberculosis: Surgical Treatment Including Collapse Therapy, Surg., Gynec. & Obst. **68**:390-394 (Feb., no. 2A) 1939.

17. Alpert, L.: The Incidence of Tuberculous Infection in Surgically Removed Tonsils, New England J. Med. **218**:1011-1012 (June 16) 1938.

their tonsils demonstrated histologically, while of the 30 with pulmonary disease 6 had tonsils containing tubercle bacilli. There was no clinical evidence of tonsillar tuberculosis in any of these children.

More interesting, perhaps, is the report of Long, Seibert and Gonzalez,[18] which is concerned with the histologic examination of a large number of tonsils: 1,000 pairs from Indian reservations, 600 pairs from Puerto Rico and 300 pairs from Philadelphia. The incidence of tuberculosis was 6.5 per cent in the tonsils from the Indian reservations, 2.5 per cent in those from Puerto Rico and 0.3 per cent in those from Philadelphia. There is no statement in this article concerning how many of the patients of the whole group had pulmonary lesions. However, the authors thought that at least the majority of them should be considered to have had primary disease of the tonsils, and in their discussion they intimated that tonsils may occasionally be infected from the cervical lymph nodes. In the cases in which the disease in the tonsil was primary, the lesion was more limited than in those in which it was apparently secondary, and when there was a frank adult type of pulmonary tuberculosis the infection of the tonsil was probably from the sputum coughed up from the lungs.

Zollmer[19] expressed the belief that tuberculosis has a particular affinity for adenoid tissue and that the faucial tonsils are especially susceptible to this infection, though statistics to date are not sufficiently reliable so that the frequency of this disease may be determined exactly. It is important to remember that tuberculosis of the tonsils may not be evidenced clinically and may be discovered only when the tonsils are examined histologically. The author asserted that deposits in the tonsils are usually hematogenous in origin, though in cases of pulmonary tuberculosis, in which they are more commonly found, the infection may come directly from the pulmonary sputum. The relation of tonsillar tuberculosis to tuberculosis of the cervical lymph nodes is shown by the fact that in 50 per cent of the cases of tuberculous cervical adenitis there was coexistent tuberculosis of the tonsils. When the tonsillar lesion can be recognized clinically, there is either ulceration or tumor formation. The tumors may reach considerable size. The ulcerative process is more commonly visible in cases in which the lesion is secondary to pulmonary disease. The author expressed the belief that the appearance of small miliary tubercles in the mucous membrane of the posterior pharyngeal wall or on the soft palate is evidence of their hematogenous origin, though sometimes when the disease involves the soft palate it is of the exudative type, in which there are small whitish elevations on

18. Long, E. R.; Seibert, M. V., and Gonzalez, L. M.: The Incidence of Tuberculosis of the Tonsil, Tr. A. Am. Physicians **53**:289-298, 1938.

19. Zollmer, F.: Tuberculosis of the Nose and Throat, Ergebn. d. ges. Tuberk.-Forsch. **9**:71-108, 1939.

a bright red mucous membrane, with a tendency to break down quickly and form ulcerations. He said that "bloody surgical treatment" often leads to dissemination of the condition and should be limited to the removal of small tuberculomas in those cases in which there is slight involvement of the lungs or none. He warned against the surgical removal of tonsils in cases of tuberculous cervical adenitis. He said that there is not yet enough evidence for one to judge the value of electric surgical procedures in this disease.

Zollmer, as well as a number of other authors, failed to realize the importance of the vulnerability of the crypts in the causation of tonsillar infection. It has been shown experimentally that tonsillar tuberculosis can be produced readily in an animal by simply swabbing the surface of the tonsils with a culture of tubercle bacilli or even feeding the animal with infected food. The recent reduction in the incidence of primary tuberculosis of the tonsils is due largely to the pasteurization of milk and to the more hygienic care of patients with infectious tuberculosis in recent years. The occurrence of miliary tubercles in the palate in cases of tonsillar tuberculosis is more rationally explained as due to a lymphatic spread of the disease from the tonsils through the rich network of lymph vessels in the mucosa. I might add further that in the treatment of tonsillar tuberculosis electric cauterization is the most valuable method of therapeusis available. I agree with Zollmer entirely that "bloody surgical procedures" must be avoided in the treatment of tonsillar tuberculosis.

Brown [20] directed attention to the fact that primary tuberculosis of the tonsils, as evidenced by histologic examination of tonsils routinely removed, is much less frequent than it used to be and that tuberculosis of the tonsils which does not produce clinical evidence is not of serious importance to the patient. Pulmonary tuberculosis rarely develops in patients with this type of tonsillar tuberculosis, though the condition may lead to involvement of the cervical lymph nodes. The author advised tonsillectomy in cases of cervical tuberculous adenitis, on account of the causative importance of the tonsillar infection in this disease.

Bordley and Baylor,[21] in an attempt to determine the prognosis of tuberculosis of the tonsils and cervical lymph nodes, made a follow-up study of 79 persons who had had tuberculous tonsils or adenoids removed between 1912 and 1920. He divided the patients into two groups. Group 1 included those under 14 years of age, and in this group 45

20. Brown, E. H.: Tuberculosis of the Tonsil, Southwestern Med. **23**:260-268 (Aug.) 1939.

21. Bordley, J., III, and Baylor, J. W.: Prognosis in Cases of Tuberculosis of the Tonsils, Adenoids and Cervical Lymph Nodes: A Study of Patients Followed for Eleven to Twenty-Three Years, Bull. Johns Hopkins Hosp. **63**:132-153 (Sept.) 1938.

patients were traced. Group 2 included patients over 14 years, and of these 16 were traced. In group 1 there were no subsequent deaths from intrathoracic tuberculosis, though 1 patient died from tuberculous meningitis seven months after tonsillectomy. In none of the patients of this group were there any clinical signs of intrathoracic tuberculosis at the time of operation, with the possible exception of a fibrinous pleurisy in 1 child. However, the pulmonary diagnosis in these cases was made chiefly by clinical examination.

In group 2, 11 of the 16 patients showed intrathoracic tuberculosis after the operation; 3 of them died from this disease and another from chronic nephritis. However, the authors had no information concerning how many of these patients had pulmonary tuberculosis at the time of operation, "though some of them certainly did." The pulmonary disease made its appearance usually within several months after the operation or at least within a few years. The authors concluded that the presence of tuberculosis in the tonsils, adenoids or cervical lymph nodes does not necessarily lead to pulmonary or generalized tuberculosis and that the immediate prognosis depends on the character of the disease elsewhere in the body. The relatively poor prognosis in the older group was attributable to the existence at the time of operation of pulmonary tuberculosis of the adult type.

Pollard and Combs [22] gave a fairly complete review of the literature on tonsillar tuberculosis and reported the results of a follow-up study of 107 patients who between the years of 1925 and 1936 had their tonsils, adenoids or both removed. The patients ranged in age from 3 to 57 years. All of them had a thorough physical examination before the operation, which, however, did not include roentgen examination of the chest. In 3 cases active pulmonary tuberculosis developed after the operation, in another, tuberculosis of the cervical lymph nodes and in another, tuberculosis of the spine. In 9 cases in which there was pulmonary tuberculosis at the time of operation the condition was not diagnosed as such until the pathologist had submitted a report describing tubercles in the tonsils. This report prompted the taking of diagnostic roentgenograms of the chest. In 20 cases in which there was tuberculosis elsewhere than in the tonsils and adenoids, an additional lesion did not subsequently develop, and in 70 in which there was no tuberculosis other than that in the tonsils at the time of operation an additional lesion did not develop, nor was there any ill health subsequently. Of the 107 cases the pathologist reported the presence of tubercles near the crypts in 56 and tubercles in the germinal centers in 51. The authors claimed that this is an indication of hematogenous infection.

22. Pollard, H. M., and Combs, A. B.: Tuberculosis of Tonsils, Am. Rev. Tuberc. **38**:746-757 (Dec.) 1938.

They directed attention to the decrease of tuberculous infection of the tonsils and adenoids in Michigan, which bears some correlation in time with the control of tuberculosis in cattle in that state.

I disagree with Pollard and Combs that the finding of tubercles in the germinal centers of the tonsils is an indication of hematogenous infection. It is a well known pathologic fact that organisms gaining access to the parenchyma of the tonsils through the epithelium of the crypts have a tendency to stagnate in the germinal follicles. In acute suppurative tonsillitis, the abscesses forming in the parenchyma originate in the germinal follicles, and I have shown experimentally that anthrax bacilli tend to concentrate around the germinal centers. My own feeling is that hematogenous infection of the tonsils rarely, if ever, occurs and that infection of the tonsils does not occur by a retrograde lymphatic route from the cervical lymph nodes. The lymph nodes are infected from the tonsils.

Dr. A. A. S. Giordano abstracted the articles by Chiray and Mollard and by C. Bosche.

# Abstracts from Current Literature

## Ear

OBSERVATIONS ON SEVEN HUNDRED AND NINETY-THREE CASES OF ACUTE PURULENT OTITIS MEDIA WITH CHEMOTHERAPY IN THREE HUNDRED AND NINETY-SIX CASES. WESLEY C. BOWERS, J. A. M. A. **115**:178 (July 20) 1940.

Bowers reports his analysis of 793 cases of acute purulent otitis media from private practice and the otolaryngologic service of St. Luke's Hospital. Bacteriologic studies are reviewed, and many mastoid cases are commented on.

The author has secured best results by using sulfanilamide in larger doses for the first day, an amount to total slightly less than 1 grain (0.06 Gm.) per pound of body weight up to 90 pounds (41 Kg.), and by lessening the dosage the following days.

He concludes as follows: "If chemotherapy is given early, before bone destruction occurs, the duration of discharge is dimished by about 50 per cent and the number of mastoidectomies is diminished by about 50 per cent.

"When the clinical picture strongly suggests mastoidectomy, it is safer to operate.

"After uncomplicated mastoidectomy, it is better not to give the drug.

"At times it is necessary to stop the drug in order to obtain the true picture, as the drug cures the middle ear while progressive bone destruction is taking place in the mastoid."

Chemotherapy (along with other tested procedures) has been of great aid in controlling otitis media and mastoiditis.

GORDON, Philadelphia.

EARLY RESULTS OF THE SURGICAL TREATMENT OF OTOSCLEROSIS. A. SERCER, Ztschr. f. Hals-, Nasen- u. Ohrenh. **46**:331, 1939.

Sercer describes his technic of making a fistula in the bony labyrinth for improving the hearing in patients with otosclerosis. In effect, his method is a modification of the Holmgren technic. He employs a retroauricular incision and exposes the mastoid, which he exenterates. This exenteration does not have to be thorough or complete but should be sufficient to give a wide approach to the lateral semicircular canal. A wide atticoantrotomy is performed, making a free exposure of the posterior and the superior bony wall of the external auditory canal. If during this procedure the skin is accidentally torn, he makes a plastic flap and interrupts the operation at this time, so as to permit complete epithelization.

The second step is then performed. He removes the incus and amputates the head of the malleus. This will permit the flap of the cutaneous posterior canal wall to cover the semicircular canal. The flap is tongue shaped, with a broad pedicle; its base is in the incisura Rivini and it appears as a projection of the drum membrane. It is thinned down and should extend far enough to cover the lateral semicircular canal and so form a wide communication with the external auditory canal. In addition to this, he makes a T-shaped flap in the external auditory canal, to permit easier drainage and a more ready approach.

He then cleanses the operative field and with a fine chisel opens the lateral semicircular canal. This opening is carefully widened with sharp curets. It is then covered with a previously prepared sheet of gold foil. This foil is firmly fixed in place over the fistula, and then the prepared skin flap is covered over and held in place by tampons of iodoform-treated gauze. The posterior incision is closed by sutures, and the entire postoperative treatment is continued through the external auditory canal. The tampon over the skin flap remains in place for a week. After its removal, the author cleanses the wound by irrigations of alcohol.

No complications have occurred as an immediate result of the operation, although in 2 cases the gold foil was expelled. Such symptoms, as vertigo, nystagmus, nausea and vomiting have occurred immediately after the fistulization, but these gradually subsided within a week. Sercer believes that these symptoms vary in intensity, being more severe in the more recent cases and either mild or altogether absent when the symptoms of otosclerosis have been present for a long time.

All of his patients showed improvement in hearing, which, however, generally was purely subjective, the degree in all but a few cases being impossible to determine quantitatively by audiometric or other methods of measurement. In consequence, he feels that the few quantitative measurements should not be considered of any real significance. Tinnitus was invariably favorably influenced. He had to deal with a few relapses, which he believes were due either to closure of the fistula or to increase of the perilabyrinthine pressure. He released this pressure, with an improvement both in hearing and in tinnitus.

He believes that the patient is not made any worse by the operation, and, since this is one of the few procedures that have shown any results in alleviating deafness in patients with otosclerosis, he recommends that patients with this disease should be given the benefit of the operation. Should the fistula close, it is easily reopened, and the secondary results are equally satisfactory.

In closing he suggests that a further modification, which will combine the Wittmaack "aeration of the dura" and the "fenestration of the labyrinthine capsule," be made a means of benefiting these patients in the future.

PERSKY, Philadelphia.

INDICATIONS FOR THE TRANSLABYRINTHINE OPERATION (IN THE TREATMENT OF OTITIC MENINGITIS). LANGENBECK, Ztschr. f. Hals-, Nasen- u. Ohrenh. **46**: 380, 1939.

Langenbeck discusses the translabyrinthine approach to deep-seated collections of pus in the petrous bone. In his series of 5 cases of meningitis there were 2 cures and 3 deaths.

A histologic study of the temporal bones in 26 cases of otitic meningitis revealed that a deep-seated collection of pus extended (1) to the tip of the petrous pyramid in 4 cases, (2) to the tegmen over the internal auditory meatus in 5 cases, (3) to the sublabyrinthine region in 4 cases, (4) to the suprameatal or inframeatal (or labyrinthine) region in 8 cases and (5) to the entire perilabyrinthine region in 5 cases. In analyzing this series, the author observed that the suppurative process that is confined to the petrous tip alone is less frequently a factor in fatal meningitis. In most of the cases there was a deep-seated focus back of the labyrinth, i. e., between the internal auditory meatus, the cochlea or the labyrinth and the posterior fossa. Consequently, he considers that this is the region to approach for a successful drainage of any deep-seated purulent collection. Roentgen diagnosis, while it may be an aid in the first group of cases (in which there is a frank suppurative process extending into the very tip of the petrosa), is not of any real assistance in localizing the suppurative process in the cases of any of the other four groups. Clinically it is not possible to differentiate definitely the various sites of infection. However, surgically it is less important to attempt to drain the petrous tip than to open the aforementioned space between the labyrinth and the posterior fossa. If in cases of meningitis such as these one has exposed the dura of the middle and posterior fossa and has been somewhat dissatisfied with the findings, a translabyrinthine approach should be undertaken to reach the retrolabyrinthine space. The author describes his technic for this. First a complete radical mastoidectomy is performed; the tegmen tympani is removed; the dura is elevated, and then the superior semicircular canal is lowered, with a wide exposure to the retrolabyrinthine space. The second step, or the exposure of the retrolabyrinthine space, is then performed.

The dura is carefully retracted from all surfaces of the pyramid. Particular care should be taken not to injure the saccus endolymphaticus. The superior surface of the pyramid is broken into in the region of the superior canal. Then all the cells, both supralabyrinthine and infralabyrinthine, can be reached and exenterated. The cells surrounding the internal auditory meatus are finally evacuated.

Langenbeck concludes that an early diagnosis of the infection is important, so that an early evacuation is possible, for if the suppuration progresses to the stage of either thrombosis of the superior petrosal sinus or frank suppuration of the dura, the prognosis is grave. A virulent epidural abscess in this region can easily spread and involve the superior petrosal sinus, from which, in turn, infection will spread back and ultimately involve the cavernous sinus.

PERSKY, Philadelphia.

MOVEMENTS OF THE TYMPANIC MEMBRANE AND OF THE MALLEUS IN PERSONS WITH NORMAL EARS AND IN PERSONS WITH OTOSCLEROSIS. PAUL FRENCKNER, Acta oto-laryng. **27**:587, 1939.

Frenckner points out that previous studies of the movements of the tympanic membrane and the ossicular chain have been made on sectioned material and not on living human beings. After going through the literature, he agrees with what Voltolini pointed out in 1858: "Frequently, but by no means invariably, as shown in the author's case, ankylosis of the stapes is associated with ankylosis of other auditory ossicles, so that the tympanic membrane is immovable." He directs attention to the advisability of examining the movements of the malleus with a Siegel-Brüning otoscope, in which Holmgren has placed two parallel hairs, between which the handle of the malleus is focused for observation. When the malleus is so observed while one is making compression or aspiration by way of the otoscope, it appears that the structure on change of pressure executes its principal movements in the form of a rotation around its own long axis or, rather, around an axis which lies somewhat behind the handle of the malleus and directed so that its upper extremity inclines somewhat toward the tympanic membrane. It seems as though the handle moves along the surface of a conceivable cone with its apex upward. It therefore moves more in its lower than in its upper portion and more on compression than on aspiration. In addition to this parallel displacement, there is a hingelike movement at the malleoincudal joint.

Frenckner photographed these movements by a carefully described technic. By projecting the film on a screen and stopping it at the places of maximum excursion, he was able to compute the degree of motion of various portions of the handle of the malleus. These moving pictures were made not only in cases in which the drum was normal but in cases of otosclerosis as well. He found that in certain of the cases of otosclerosis the parallel displacement of the handle of the malleus was practically suspended, although the hingelike movement remained. In other cases of otosclerosis the movements of the malleus and the tympanic membrane were the same as in cases in which the drum was normal. Frenckner therefore concludes that:

The principal movement of the malleus is a parallel displacement perpendicular to its own long axis. There is also, to a lesser extent, a certain hingelike movement.

The parallel displacement of the contour of the malleus seems to take place through the rotation of the hammer around its own long axis.

In certain cases of otosclerosis the mobility of the malleus is arrested to a great extent or entirely suspended. This arrest is due mainly to a cessation of the so-called parallel displacement.

The peculiarly constructed malleoincudal joint permits the rotation of the malleus around its own axis. The decreased mobility of the handle of the malleus in otosclerosis may be due to an otosclerotic change in the malleoincudal joint or in the neighborhood of its surfaces.

GROVE, Milwaukee.

ON THE FREQUENCY OF OTOSCLEROSIS. HANS ENGSTRÖM, Acta oto-laryng. **27**: 608, 1939.

Engström tried to get from sectioned material some idea of the frequency of otosclerosis, and this paper is a preliminary report, showing the incidence of the disease in 61 temporal bones from 34 unselected persons aged 30 to 90 years.

1. There was otosclerosis in 4 of the 34 cases.

2. In these 4 cases the otosclerotic process was bilateral.

3. In 2 of the cases the otosclerosis was localized to the region of the oval window, with exostotic processes and thickenings of the annular ligament. There was in no case a bony ankylosis. The history and histologic observations were compatible with a hearing defect of long standing and, in 1 case, vertigo.

4. In the other 2 cases the otosclerosis was more diffuse in the labyrinthine capsule and had no connection with structures important for sound conduction or perception. In these 2 cases there was no reported history of cochlear or vestibular symptoms. Histologically the changes, except for certain small spongy areas, were mainly of the type described by Manasse as "blue mantle."

Engström's finding of otosclerosis in 4 of 34 persons, or about 10.5 per cent, corroborates the findings of M. Weber (1935) and of Nager (1938) of approximately a 10 per cent incidence of otosclerotic changes in all bones examined.

GROVE, Milwaukee.

THE MANAGEMENT AND TREATMENT OF FACIAL PALSY. EDMUND P. FOWLER JR., Acta oto-laryng. **27**:615, 1939.

This is an excellent summary of what is known concerning the diagnosis, localization, treatment and prognosis of paralysis of the facial nerves. There is nothing particularly new in the paper, but the entire subject is presented in a comprehensive and thorough manner. The results of five years' experience in the treatment of facial paralysis in the Presbyterian Hospital, New York, are reviewed with the following conclusions:

1. Accidental operative injuries of the facial nerve should be explored at once by decompressing the canal to the point of injury and slitting the nerve sheath in the entire extent of the exploration.

2. When accidental operative injury is followed by a considerable facial paralysis months or even years after the injury, the nerve should be explored and grafted according to the Ballance-Duel method, but Fowler has abandoned Duel's method of completely sectioning the nerve above and below the point of injury, preferring to leave the few remaining viable fibers of the nerve in the trough.

3. If there is little paralysis and merely annoying associated movements, operation is contraindicated.

4. If the facial nerve is injured by a bullet, exploration of the fallopian canal is indicated.

5. Exploration of the facial canal following palsy due to skull fractures is theoretically contraindicated.

6. In toxic neuritis the canal should be decompressed if faradic stimulation disappears or if there is repeated paralysis.

7. The occurrence of facial paralysis three or four days after a mastoid operation does not indicate immediate operation on the facial canal.

8. Facial paralysis in association with acute otitis media or with mastoiditis does not require immediate operation on the facial canal.

9. During the period of repair of the facial nerve, the patient should receive massage and galvanic stimulation to the affected muscles to prevent atrophy and as soon as innervation has taken place should be taught to exercise the affected musculature.

Fowler states that except in young children very rarely does the facial nerve show a highly satisfactory degree of repair, and for this reason and to improve the cosmetic effect he recommends that after a year or two transplants be made from the buccinator, the masseter or the temporal muscle. GROVE, Milwaukee.

SURGICAL TREATMENT OF MORBUS MÉNIÈRE. ERIK BERGGREN, Acta oto-laryng. **27**:626, 1939.

Berggren describes a method of injecting alcohol into the vestibule of the ear in the treatment of Ménière's disease of severe intensity and directs attention to the fact that Mollison has previously reported on the same treatment by a different approach. He uses this treatment only in cases in which the disease is disabling, in those in which it has resisted long-continued medication with phenobarbital and similar barbiturates and in those in which the hearing is either extremely defective or entirely gone. Through an ear speculum he makes a flap of the entire posterior half of the tympanic membrane and turns it forward and upward. After scarifying the surface of the promontory, he uses a motor-driven dental burr to perforate the bone of the promontory. When the membranous canal is reached, he extracts the endolymph by suction through a septum syringe and then injects a few drops of alcohol. Then the flap of tympanic membrane is pushed against the fistula with a tampon of iodoform-treated gauze, which is left in place for ten days, when, after being softened with chloramine-T, it is removed. If the hearing of the ear is relatively good and the symptoms cannot be controlled by a lengthy treatment with phenobarbital and belladonna, he advises differential section of the vestibular portion of the eighth nerve as recommended by Dandy.

GROVE, Milwaukee.

## Pharynx

SEPSIS FOLLOWING PHARYNGEAL INFECTIONS. COLBY HALL, Ann. Otol., Rhin. & Laryng. **48**:905 (Dec.) 1939.

Hall discusses general sepsis originating in the pharynx or the pharyngomaxillary space, its extension via the jugular vein and the latter's tributaries and the meager signs of local involvement. The taking of a careful history and a knowledge of the anatomy and pathology of the region are necessary to reach the proper diagnosis.

There are three routes by which infection may reach the general circulation from the pharynx: (1) the phlebitic, (2) the phlegmonous and (3) the lymphatic. In a given case an infection may be carried by any one of these routes or by a combination of them.

A thrombophlebitic process arising in the small veins of the pharynx reaches the general circulation through the common facial veins flowing into the internal jugular vein. Occasionally the anterior and posterior facial veins and a few small pharyngeal veins enter the jugular vein independently. Once the jugular vein is involved, there may be retrograde involvement of the lateral sinus.

In the phlegmonous route the main considerations are with the pharyngomaxillary space. Infection there may cause involvement of the internal jugular vein by periphlebitis or thrombophlebitis. The signs of pharyngomaxillary phlegmon are: (1) extreme trismus, (2) induration and swelling over the parotid gland, extending below the angle of the jaw, (3) obliteration of the subangular space beneath the angle of the jaw and (4) peritonsillar swelling and induration with little or no pharyngeal inflammation.

The lymphatic route involving the perijugular lymphatics is frequently written about, but the author has not had much experience with infections spread by this route.

General sepsis may follow the pharyngeal infection immediately or may not appear for from several days to several weeks after its subsidence. Diagnosis of the type of infection which is carried by the phlegmonous route and involves

the peritonsillar or the pharyngomaxillary areas is not difficult, but when the infection is carried purely by the phlebitic route the signs are few and the source of the sepsis is easily overlooked. In the presence of a severe sepsis, when there is a history of recent pharyngeal infection surgical investigation is urgent. If there is any doubt, the jugular vein should be inspected, as a few hours' delay may doom the patient. In any case, if the neck is opened both the carotid sheath and the pharyngomaxillary fossa should be inspected. A pharyngomaxillary phlegmon not responding to chemotherapy within forty-eight hours should have external drainage and possibly venous ligation. If throat signs are vague or absent, the history of local pain in the throat or neck may be of great help in determining the side to be investigated. The author says that even in his most difficult cases there has been some slight obliteration and tenderness of the subangular space" on the involved side. Eight cases are reported. M. V. Miller, Philadelphia.

Bismuth Therapy in Acute Tonsillitis: Experimental Demonstration of the Rapid Invasion of Tonsillar Tissues by Bismuth Salts. V. Pescetti, Arch. ital. di otol. **51**:607 (Dec.) 1939.

In 1933 Monteiro reported the treatment of 50 patients with acute tonsillitis by intramuscular injection of bismuth salts. Forty-eight of the patients were cured in from twenty-four to forty-eight hours. He thought that those infections (chiefly peritonsillar) which did not respond were Staphylococcus infections. These infections are not so amenable to the curative action of bismuth—a conclusion not supported by other investigators. Since 1934 many patients have been treated by the injection of bismuth salts in Ferreri's clinic, and the results obtained by Monteiro have been fully confirmed. Pescetti carried out histologic studies on 8 patients to determine the mechanics of the curative action of bismuth in acute tonsillitis. A bismuth compound was injected into the muscles some hours before the tonsils were removed, and examination of the tissues revealed that it was present within eight or nine hours after the injection. After twenty-four hours the entire tonsil was infiltrated with bismuth. These results harmonize with the clinical results, since abatement of the symptoms begins when the metal arrives in the tonsil and exercises its bactericidal action. The patients usually become entirely normal in twenty-four to forty-eight hours. A convincing colored photomicrograph accompanies the article. Dennis, San Diego, Calif.

Treatment of Lupus Erythematosus of the Mouth. H. Leicher, Ztschr. f. Hals-, Nasen- u. Ohrenh. **46**:81, 1939.

After discussing in detail the differential diagnosis of lupus erythematosus, Leicher considers the various methods of treatment, mentioning the use of bismuth, gold, potassium iodide, the local application of solid carbon dioxide and roentgen irradiation. He stresses the unsatisfactory results that have been obtained by all of these measures. He reports a series of 4 cases, in 3 of which cures were effected by electrocoagulation of the lesion. Persky, Philadelphia.

## Larynx

Severe Injury to the Larynx from the Indwelling Duodenal Tube (Case Reports). Samuel Iglauer, Ann. Otol., Rhin. & Laryng. **48**:886 (Dec.) 1939.

It is undoubtedly true that in the vast majority of cases the indwelling duodenal tube does no injury, yet in a small number it is the cause of serious involvement of the larynx. In the cases reported, the tube was indwelling for periods varying from six to twenty days, the average being eight and one-half days. In most cases the signs of laryngeal involvement first appeared after permanent

removal of the tube and included pain, dysphagia, blood-streaked sputum, hoarseness, croupy cough and more or less dyspnea. Tracheotomy became necessary in all but 2 of the 10 cases. The original ulceration is in the upper end of the esophagus and is most likely due to the fact that there is a sphincteric action there which keeps that end of the esophagus closed, pressing the indwelling tube between the cricoid cartilage and the vertebral column. The pressure, together with friction from swallowing, vomiting and other movements, produces the involvement. The irritation produces a perichondritis of the cricoid cartilage, which may extend to the interior of the larynx and cause subglottic stenosis or fixation of the arytenoids. The acute stage is followed by fibrosis, with cicatricial stenosis of the larynx. Acute stenosis often calls for tracheotomy, while fibrotic stenosis may cause the patient to become permanently dependent on the use of a tube.

In the presence of an indwelling duodenal tube, any symptoms pointing to esophageal or laryngeal involvement call for immediate laryngoscopic procedure. The tube should be removed at once if the larynx or hypopharynx shows any signs of involvement.

M. V. Miller, Philadelphia.

Indications for Direct Laryngoscopy. C. L. Jackson, Ann. Otol., Rhin. & Laryng. **48**:926 (Dec.) 1939.

In children, obstructive laryngeal dyspnea, stridor, wheezing, hoarseness or aphonia calls for direct laryngoscopic examination. The most common cause of stridor in infancy is congenital deformity of the epiglottis and subglottic aperture. Direct laryngoscopic procedure is necessary, also for the removal of foreign bodies, for obtaining secretion directly from the larynx or trachea for bacteriologic study and also, in asphyxia neonatorum, for aspiration of laryngeal and tracheal secretions, to exclude a high obstruction.

Adult patients requiring direct laryngoscopic procedure may be divided into two classes: those in whom the larynx is imperfectly visualized by the mirror and those in whom the view by the mirror is satisfactory but a condition is seen which calls for biopsy, surgical intervention or dilatation. Asphyxial death of a drunken, injured or anesthetized patient may sometimes be prevented by lifting the tongue forward by means of the laryngoscope, a catheter or intubation tube being introduced to maintain the airway if necessary.

M. V. Miller, Philadelphia.

Technic of Laryngofissure. T. Zalewski, Monatschr. f. Ohrenh. **12**:756 (Dec.) 1939.

To open the thyroid cartilage in a laryngofissure, if the scalpel is not strong enough a gage and mallet are used after the larynx has been fixed in the proper median position. The use of the circular saw also produces good results. In the closure, the soft parts are brought together in layers, but no sutures are made in the cartilage. In the author's experience, primary tracheotomy does not seem to be indicated.

Lederer, Chicago.

## Miscellaneous

The Significance of the Oxidation of Sulphanilamide During Therapy. Charles L. Fox Jr., Am. J. M. Sc. **199**:487 (April) 1940.

The fact that methemoglobin occurs in the blood of patients treated with sulfanilamide suggested to the author that, since methemoglobin is formed from hemoglobin only by strong oxidizing agents, a rather powerful oxidizing agent is formed during sulfanilamide therapy. Sulfanilamide is not itself an oxidizing agent, but it may be oxidized by exposure to ultraviolet rays to a blue solution, which probably contains several products and which oxidizes hemoglobin to methemoglobin. There is a considerable amount of evidence that when bacterial growth is suppressed by sulfanilamide the drug itself is oxidized. The products

of oxidation then apparently act as an oxidizing agent to inhibit the growth of bacteria. Oxidation of sulfanilamide requires the presence of oxygen. Therefore, in cases of septicemia the drug is in the presence of oxygen (in the blood stream) and is effective, whereas in closed abscesses the drug is in an environment poor in oxygen and is ineffective. The action of the oxidizing sulfanilamide derivative on bacterial growth seems to rest on the inactivation of enzymes essential to bacterial growth.

GEORGE E. SHAMBAUGH JR., Chicago.

MYCOTIC INFECTIONS OF THE BRONCHO-PULMONARY TRACT. A. J. VADALA, Ann. Otol., Rhin. & Laryng. **49**:291 (June) 1940.

The author gives a comprehensive review of fungous infection of the bronchopulmonary tract. For clinical purposes the fungi invading the bronchopulmonary tract are conveniently classified into (1) yeastlike organisms, such as Cryptococcus, Oidium, Monilia and Saccharomyces and (2) filamentous forms, such as Actinomyces.

Discussing the general symptoms of mycotic infection of the lungs, the author says that the disease may run a mild course, with a few symptoms, the clinical course resembling that of chronic bronchitis. These conditions frequently clear up without any complications. On the other hand, there is another type of the infection, which runs a malignant course. The patient loses weight and has a cough with hemoptysis, and the sputum frequently has a nauseating foul odor, which is helpful in making the diagnosis. The physical signs and character of the disease resemble those of tuberculosis. Examination of the chest may show rales and dull areas. Roentgen signs cannot be differentiated from those present in cases of tuberculosis. Final diagnosis depends on aspirating some exudate with the bronchoscope and making cultures of the material on specially prepared mediums.

Infection with the various types of fungus is discussed at some length, and the author describes signs, distribution, diagnosis and treatment. The iodides are extremely effective in the treatment of many types of fungous infection, but because of the difficulty in making a differential diagnosis between these and tuberculosis, the reader is warned to be sure of the diagnosis before giving the iodides. Specific therapy and nonspecific therapy have been used, with conflicting reports resulting. The former, however, is a help in diagnosing some cases.

The use of irradiation, combined with either surgical treatment or the administration of iodides, is discussed in connection with actinomycoses. Various treatments for the various types are considered and one gets a complete picture of the present day knowledge of this troublesome infection. Full case reports of 10 patients are presented.

M. V. MILLER, Philadelphia.

CYSTS, SINUSES AND FISTULAE OF THE THYROGLOSSAL DUCT: RESULTS IN TWO HUNDRED AND NINETY-THREE SURGICAL CASES. J. DEJ. PEMBERTON and L. K. STALKER, Ann. Surg. **111**:950 (June) 1940.

Cysts of the thyroglossal duct may arise anywhere in the midline along the vestigial thyroglossal tract in its pathway from the base of the tongue to the region between the hyoid bone and the thyroid gland. Clinically the cyst occurs far more commonly below the level of the hyoid bone than above it. A series of 293 cases was reviewed, and 261 of the patients were satisfactorily traced as to the possibility of recurrence. Only 4 recurrences were noted. This result was in contrast to the 166 recurrences which were listed among the 261 patients before the last operation. The method employed is the modified Sistrunk operation. When a sinus is present, it is injected with methylene blue, and an elliptic transverse incision is made to include the sinus. The cyst is dissected free, the central portion of the hyoid bone is resected and the tissue up to the foramen caecum is cored out. The sex ratio in the cases reviewed was 2 males to 1 female. Opera-

tion was performed on only 32 patients who were less than 10 years of age. One hundred and forty-four patients were between the ages of 10 and 40; 90 were between 30 and 50 years and 27 beyond the age of 60 when the Sistrunk operation was performed.

H. A. MILLER, Philadelphia.

THE UNSOLVED PROBLEMS IN APHASIA: II. ALEXIA RESULTING FROM A TEMPORAL LESION. J. M. NIELSEN, Bull. Los Angeles Neurol. Soc. **4**:168 (Dec.) 1939.

From a study of 13 cases selected on review of the neurologic literature and 3 cases observed personally, Nielsen concludes that lesions involving the posterior portion of the major (left) superior temporal convolution, leaving the angular gyrus intact, destroy or seriously reduce comprehension of the significance of words which the patient can recognize by sight. Nielsen's attention was directed particularly to that part of the superior temporal convolution lying between Wernicke's center for comprehension of spoken words and the angular gyrus, which mediates the recognition of printed words. This area is not yet anatomically recognizable by cytoarchitectural or myelogenetic studies. However, lesions confined to the angular gyrus destroy recognition of the printed word while leaving comprehension of the spoken word intact; this demonstrates that (1) comprehension of the spoken word does not depend on its visual recognition, (2) the major (left) angular gyrus mediates recognition of the printed word and (3) the posterior limit of the area in question for comprehension of the printed word is the angular gyrus. On the other hand, with a few exceptions, lesions of the major (left) superior temporal convolution with preservation of the angular gyrus destroy comprehension of the printed as well as of the spoken word. Thus Henschen's postulate that comprehension of the spoken word is necessary for comprehension of the written word is usually true.

From these facts it is concluded that deletion of the recently acquired function of recognition of written symbols does not interfere with the already thoroughly established comprehension of spoken language; that the area concerned with the comprehension of the visual word extends from Wernicke's center into the angular gyrus, and that such comprehension of the written word is dependent on association of the angular gyrus with Wernicke's area, while comprehension of the spoken word is not dependent on such association.

MACKAY, Chicago. [ARCH. NEUROL. & PSYCHIAT.]

PHYSIOPATHOLOGY OF THE FRONTAL LOBES. L. BARRAQUER, Rev. neurol. **72**:160, 1939.

A girl aged 8 years had headache, vomiting, pallor of the optic disks, ataxia, muscular hypotonia, disorientation and left hemiparesis. Death followed craniotomy. Necropsy revealed an enormous sarcoma of the right frontal lobe. The cerebellum was intact. The hypotonia was exclusively of frontal origin. Walking in circles and disorientation in space are known results of any lesion of the frontal lobe. In a girl aged 14 suffering from a craniocerebral wound in the left frontal region, both of these symptoms were observed. Craniotomy revealed several fragments of bone, as well as hair, embedded in the brain. The foreign bodies were removed, and the patient recovered. These 2 cases are presented because of the undeniable lesions of the frontal lobe.

LIBER, New York. [ARCH. NEUROL. & PSYCHIAT.]

# Society Transactions

## CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

ROBERT H. GOOD, M.D., *President*

WALTER H. THEOBALD, M.D., *Secretary*

*Regular Monthly Meeting, Dec. 2, 1940*

**Otosclerosis in Identical Twins.** DR. ELMER W. HAGENS.

This article will appear in full in a later issue of the ARCHIVES.

DISCUSSION

DR. GEORGE E. SHAMBAUGH JR.: Identical twins develop from a single ovum, so that presumably all inherited factors are shared equally. It would seem that otosclerosis in identical twins offers the ideal opportunity for determining the importance of heredity in comparison with external factors in this mysterious disease. However, there may be one complicating factor in the situation. It is said that identical twins are no more alike than are the left and the right side of a person, since one twin develops from the right half of the ovum at its first division and represents the right half of the person originally intended, while the other twin represents the left half. Deafness in otosclerosis is not always symmetric but frequently develops earlier or more rapidly in one ear. F. R. Nager found that in 10 per cent of cases the deafness is confined to one ear. Therefore, when clinical otosclerosis develops sooner in one identical twin than in the other, it may mean only that the person originally intended would have become deaf in one ear first.

Considering this complicating factor, it is remarkable that otosclerosis runs a similar course in all the identical twins in whom the disease has thus far been reported. Dr. Hagens' case represents a valuable addition to the the 5 cases previously reported. It suggests but does not prove the importance of pregnancy as an accelerating factor in the deafness of otosclerosis. The importance of pregnancy in otosclerosis probably has been exaggerated. My own experience indicates that there is only a 1 in 5 chance of a further loss from pregnancy, while Nager found the chances to be 1 in 4.8. More cases like Dr. Hagens' will help to prove the importance of pregnancy and perhaps of other predisposing factors in the deafness of otosclerosis.

DR. ALFRED LEWY: Are there any cases on record of unilateral deafness in identical twins?

DR. SAMUEL SALINGER: I should like to ask whether in these cases the basal metabolic rate was determined or a determination of the blood calcium was made. Such data might or might not be of value as corroborative evidence in evaluating the differences in the hearing ranges.

DR. ELMER W. HAGENS: In answer to Dr. Lewy, I believe that otosclerosis in all cases is bilateral. In reply to Dr. Salinger, I did not ascertain the basal metabolism of these girls, because soon after I examined them one moved away and has just recently returned. However, the basal metabolic rate has been mentioned as one of the significant findings in cases of this type.

**Anesthesia in Otolaryngology.** DR. STUART C. CULLEN, Iowa City.

An attempt will be made to show how a knowledge of certain fundamentals in anesthesia, such as the use of proper preanesthetic medication and the maintenance of an adequate airway and a sufficient supply of oxygen, can increase the con-

venience to the surgeon and the comfort of the patient and minimize the hazard to the patient. Individual study of each patient relative to the anesthetic agent and technic to be employed is an indispensable accompaniment of good anesthesia.

Premedication has several functions, all of which influence only the anesthesia; it influences the surgical procedure only so far as it aids or hinders the anesthesia. As a consequence, the drug selected, the amount used and the time it is given should be determined with reference to the anesthetic agent and technic employed.

The functions of preanesthetic medication are the allaying of apprehension, the heightening of the threshold of pain, the lowering of metabolic activity and certain specific actions, such as the drying of secretions.

Of the drugs commonly used, morphine is the most efficient, producing the greatest depression of reflex irritability, analgesia and reduction of metabolism with the least interference with the normal protective mechanisms. The maximum action of morphine should be obtained before the induction of anesthesia is instituted. If this is not done, the benefits to be derived from premedication are minimal, difficulty with the induction and maintenance of anesthesia is frequent and prolonged severe depression supervenes postoperatively. When given subcutaneously, morphine reaches peak effect in sixty to ninety minutes; given intramuscularly, it reaches maximum effect in thirty to forty-five minutes, and when it is given intravenously, the total action occurs in ten to twenty minutes. The same dose may be used for all three routes. When given intravenously, morphine sulfate should be used diluted with approximately 5 cc. of saline solution or water and given slowly over a period of two to three minutes.

Scopolamine and atropine have two functions in common: (1) the prevention of secretion and (2) the reduction or elimination of certain vagally mediated reflexes. In addition to these functions scopolamine produces marked psychic sedation and amnesia and is to be preferred for premedication over atropine.

The barbiturates have two functions: (1) hypnosis and (2) protection against the convulsive manifestations of a cocaine or similar drug reaction. The short-acting barbiturates, the maximum effect of which is obtained in twenty to thirty minutes when they are given by mouth, are preferred and when administered in combination with morphine and scopolamine should be given one-half hour before those drugs.

Morphine sulfate and scopolamine hydrobromide are used in the ratio of 25 parts of morphine sulfate to 1 part of scopolamine hydrobromide. This combination produces a minimum of respiratory depression, nausea and emesis, with a maximum of benefit. The dosage is dependent on a number of factors influencing the metabolic activity of the patient.

The use of routine doses of the drugs mentioned can result only in unsatisfactory anesthesia in a large proportion of cases. The scientifically individualized use of these drugs can make the difference between a successful operation and an unsuccessful one, particularly under regional, topical or infiltration anesthetic technics.

The establishment and maintenance of an adequate airway is a prime consideration in any anesthesia and particularly significant in otolaryngologic anesthesia when surgical procedures about the upper respiratory passages are being carried out.

The most important contribution to the maintenance of an airway during anesthesia is the employment of an endotracheal technic. This assures a patent airway in all positions, facilitates removal of the anesthetist from the field, prevents aspiration of blood or mucus, allows for suction and cleansing of the trachea and bronchi, reduces the amount and concentration of agent necessary and permits manipulation about and full vision of the face and pharynx without interfering with the anesthesia.

The difference between good and poor anesthesia is usually the difference between a good airway and a poor one. All too frequently the death of a patient under anesthesia can be ascribed to an inadequate airway.

Regional, infiltrational and topical induction of anesthesia in otolaryngologic practice are most conveniently performed by the surgeon. The anesthesiologist's principal interest in relation to these methods of inducing anesthesia is in the premedication and the treatment of reactions.

Other methods of inducing anesthesia are inhalation and rectal and intravenous injection. The induction of anesthesia by inhalation has several advantages. Minute to minute control is possible, there is no time limit, it is available to practically all patients and the cooperation of the patient is not needed. Disadvantages are that there is sometimes a delayed return of reflexes, and potent explosive agents must be used on occasion. The rectal technic has advantages in that the induction is pleasant and the agent is nonexplosive. Disadvantages are respiratory and circulatory depression, slow return of reflexes, the necessity for frequent supplementing with other agents, imperfect cooperation, impossibility of control and the production of increased laryngeal reflexes. Anesthesia induced by the intravenous administration of barbiturates is advantageous in that the induction and recovery are quick and pleasant, the agent is nonexplosive, there is no irritation of respiratory mucosa and relaxation is complete. There is, however, no means of controlling these drugs, they cause respiratory and circulatory depression and increased laryngeal reflexes and two persons are necessary for proper administration.

It should be emphasized that, contrary to popular opinion, control of the airway is as important in rectal or intravenous technics as in inhalation technics. The fact that the drugs are administered by routes other than the upper respiratory passages does not mean that the establishment and maintenance of an airway is not important. Most of the difficulty arising from the use of these technics is due to improper control of the airway.

In conclusion, it is evident that many anesthetic agents and technics are available for otolaryngologic work. It should also be evident that the agents and technics in themselves are of little value unless utilized by a person capable of selecting and maintaining the type of anesthesia best suited to each occasion. This capability is most frequently obtained in a physician who is able to apply physiologic fundamentals.

DISCUSSION

DR. THOMAS C. GALLOWAY: I am favorably impressed by Dr. Cullen's extensive premedication. Recently I have been using more premedication, almost to the point of basal anesthesia, and find that operations not satisfactory when performed with the patient under regional anesthesia are remarkably so with more premedication, and I have been rather weaned away from avertin with amylene hydrate. One should emphasize the care of the patient while he is getting the effect of premedication. At one hospital morphine and scopolamine are given while the patient is in a noisy ward, and he has to walk a distance to the operating room. The results are unhappy. The patients are likely to be tense and resistive. In another hospital the head nurse does not let any one go into the patient's room while the premedication is taking effect and even puts cotton into the patient's ears to exclude noise. These patients are relaxed and cooperative. I am glad that Dr. Cullen emphasized certain dangers that may occur with intravenous administration of an anesthetic. It is one thing to have an anesthetic administered in this manner when there is close supervision, with appreciation of the dangers, and another to delegate the task to an untrained intern. I know of two fatalities in a relatively small number of cases. I think intravenous administration appeals to otolaryngologists; it is out of the way of the field of operation and is simple, but I think it can be overused.

Another concern in the use of premedication is the abolition of the cough reflex. One must not lose sight of the fact that this reflex is most valuable in preventing pneumonia or atelectasis. Chevalier Jackson emphasized that in many cases requiring use of the bronchoscope one should not administer opiates.

I should like to have Dr. Cullen tell us what anesthetic he chooses for surgical diathermy around the head. I have used with satisfaction both avertin with

amylene hydrate and nitrogen monoxide, the latter administered intratracheally. Is there any hazard of explosion with the latter?

DR. WILLIAM H. CASSELS: First, I should like to express my appreciation of the opportunity of discussing Dr. Cullen's excellent and comprehensive paper. Few specialists recognize the difficulties of the anesthetist, and I think the otolaryngologist is one of the few who do. He is accustomed to think of the upper respiratory tract, as is the anesthetist.

Dr. Cullen emphasized the advantage of a free airway and of endotracheal administration of anesthetics in certain cases. I have encountered several cases recently which brought out one advantage in having the endotracheal apparatus; that is the facility with which one can deal with an emergency if it arises. In 2 cases there was respiratory arrest, probably due to neurologic complications. In one a cerebellar abscess resulted in respiratory arrest during mastoidectomy; in the other an operation was being performed for a retropharyngeal abscess. Respiration ceased during operation and returned spontaneously only after completion of the operation. This was probably related to pressure on the carotid sinus. In each instance the use of the endotracheal technic made it easy to control respiration and avoid complications.

I should like to offer a few constructive criticisms. Under no circumstances is it more difficult to induce anesthesia than when a surgeon has tried and failed to do an operation with the use of a local anesthetic. The operation has been started in a region the anesthetist would like to get at, the patient is stimulated by the local anesthetic, he may be suffering pain and he is psychologically disturbed, conditions which make it difficult to induce good anesthesia. In such cases the hazard for the patient is greater than that of both types of anesthesia induced separately. In the administration of either a local or a general anesthetic, a patient is subject to hazards. This is enhanced by the difficulty of inducing anesthesia under the circumstances described.

Dr. Cullen mentioned the hazards of ventricular fibrillation under general anesthesia. There are two circumstances which are likely to cause this in otolaryngologic practice. No surgeon is more addicted to the use of epinephrine than the otolaryngologist, and when epirephrine is used in packs in the nose or in a wound, some is absorbed and is apt to cause ventricular fibrillation under general anesthesia. Another circumstance is the attempt to carry out minor surgical procedures with the patient under very light anesthesia. It is known that this is likely to cause ventricular fibrillation when chloroform is used and probably also when ethyl chloride is employed. In operations such as myringotomy it is tempting to use some potent quickly acting agent. As soon as the patient is quiet, the surgeon incises the ear drum, which stimulates the patient. Perhaps the adrenals are stimulated, and ventricular fibrillation and death may occur. Even minor procedures should be regarded as hazardous when carried out with the patient under general anesthesia, and as much care should be taken as in more elaborate procedures.

I was impressed by Dr. Cullen's mention of intravenous administration of anesthetics. My associates and I have used it frequently, and our experience in several cases has made us wonder whether it is advisable. In a simple operation to remove a polyp from the ear, we injected a little pentothal sodium, and the patient started to cough and in spite of all our efforts to stop the reflex he persisted in coughing until after the operation was completed. One great hazard is the addition of more anesthetic agent. The danger is that respiration will stop before the coughing and spasm are stopped.

DR. NORA B. BRANDENBURG: As an anesthetist I am interested in this subject. Basal anesthesia should be brought to the attention of every otolaryngologist. Basal anesthesia is a state of unconsciousness produced by such drugs as pentobarbital sodium and other barbiturates commonly used in the office. It behooves all physicians to know the action of these drugs and the signs of an overdose.

I am also interested in the action of these drugs on the mucous membranes. Recently I observed a patient who had been given an overdose of pentobarbital

sodium and noted an increase in secretion from the mucous membranes of the tracheobronchial tree and the vagina. The barbiturates produce edema of the lungs, and aspiration pneumonia is the most serious complication. I have observed that certain of the popular vitamin products with nicotinic acid, even in small doses, produce similar reactions in sensitive persons. This response of the mucous membranes may account for the coughing of some of the patients under anesthesia induced with barbiturates, which was mentioned by the speaker. Anesthetization is a specialty and should be recognized as such by all members of the medical profession.

DR. B. B. LENNON: Dr. Cullen mentioned the deleterious effects of divinyl ether on the liver. It is true that such effects are produced in prolonged anesthesia. However, when vinethene is used for only five to ten minutes of anesthesia, no contraindications are found. Vinethene has not an unpleasant odor, and after several inhalations both children and adults may be brought to a pleasant degree of analgesia, from which they recover smiling in many instances, with a memory of having had a pleasant dream. At Michael Reese Hospital it has been a common experience to have a child come into the operating room crying and fearful and to go out smiling. Patients become anesthetized in a few seconds and awaken with equal rapidity.

My associates and I have found endotracheal anesthesia to be of particular importance for that type of adult patient who has been scheduled for a tonsillectomy under local anesthesia and who refuses at the last moment to go through with it. Here endotracheal administration serves a worth while purpose. The comparison of the behavior of an adult under the ordinary open drop or insufflation technic and under endotracheal administration leads one to believe that the latter method offers security and peace of mind to both surgeon and anesthetist and the protection of proper oxygenation to the patient, which are out of all proportion to the added complexity or expense of the technic.

When diathermy in the upper respiratory tract is contemplated, it is our policy to cocainize the pharynx and larynx as though for a bronchoscopic procedure, set up the apparatus for an intravenous infusion of physiologic solution of sodium chloride, inject a small amount of pentothal sodium, introduce a nasal endotracheal or an oral endotracheal tube (depending on the location of the lesion) and then maintain adequate anesthesia with at least 20 per cent oxygen and nitrogen monoxide. All the patients who are to have this type of anesthetization must be seen by the anesthetist prior to operation and given a premedication of either ⅙ grain (0.01 Gm.) of morphine sulfate and 1/150 grain (0.0004 Gm.) of scopolamine hydrobromide or ¼ grain (0.015 Gm.) of morphine sulfate and 1/100 grain (0.0006 Gm.) of scopolamine hydrobromide, in a single or a double dose, depending on the age and debility of the patient.

Endotracheal anesthetization in the hands of the expert will not result in harm to the larynx or other structures. Some surgeons fear that a tube in the respiratory tract will produce damage. I should like to cite a few cases to the contrary. The late Dr. Robert Sonnenschein, during the last four days of his illness, had an endotracheal tube in position almost constantly. This was used as an airway to allow ingress of oxygen and the removal of secretions, to prevent him from drowning in his own respiratory debris. Postmortem examination showed no deleterious effects. Recently an endotracheal tube was kept in a young girl for fifty-five hours, and postmortem findings revealed no abnormality of her respiratory tract. While Dr. Cullen and I were at Bellevue Hospital, New York, we had the opportunity to observe a patient who had an endotracheal tube in position continuously for approximately one hundred and seventy-six hours and who died about thirty-six hours after its removal, from metastatic abscess of the lung and hemorrhage. However, it was the opinion of the members of the laryngologic department that the tube had not affected the upper respiratory tract.

Some physicians object to the use of the endotracheal tube yet not to that of the bronchoscopic tube. I believe all laryngologists realize that in expert hands an endotracheal tube and endotracheal administration of the anesthetic can be a boon to every one concerned in an operation.

DR. J. ALLAN WEISS: I should like to ask Dr. Cullen to comment on the additional hazard presented by intensive sulfanilamide therapy in general anesthesia and what precautions he uses in the management of patients operated on at a time when there is a high concentration of sulfanilamide in the blood.

DR. HOWARD C. BALLENGER: For a year or so I used the scopolamine hydrobromide–morphine sulfate combination as a preoperative preparation for the induction of local anesthesia. I had 3 or 4 instances of marked respiratory depression, which I attributed to the scopolamine as I have not had this mishap after the use of morphine and atropine. Perhaps my prejudice against scopolamine is unjustified. I should like to have Dr. Cullen comment on this.

DR. G. H. MUNDT: For many years I have noted several things which are apparently not sufficiently appreciated by either the hospital personnel or the surgeon. One is that in the preparation of a patient for an ear, nose or throat operation he is given preoperative medication and wheeled up to the surgery floor and is then allowed to wait for from ten to thirty minutes. Dr. Galloway mentioned one phase of this, but I think that, in addition to having cotton in the ears, the patient should be carefully moved from his bed to a cart and taken to the surgery floor without having to sit around in a chair.

Mention has been made of myringotomy. All otolaryngologists would like to have some simple anesthetic for use on children. During the last few years I have used ether, because it seems to have an element of safety, and I think until it has been proved that some other anesthetic is as satisfactory, I shall use ether for this operation.

DR. FRANCIS LEDERER: I should like to voice a word of appreciation of those people who worked in this field long before physicians were sufficiently interested to make of anesthesia a science and a specialty. Some years ago it was impossible to interest hospital and administrative officers in employing men and women physicians who made a specialty of anesthesia. I am sure all physicians have had the services of excellent nurses who were quite competent, but anesthetization is now a science. Trained anesthetists know all about drugs and their reactions, and I feel that a great deal of progress has been made. Much of the credit is due to Dr. Ralph Waters, of Madison, Wis., who has trained many anesthetists. Physicians can entrust their patients to these specialists and know that anesthesia is properly induced and maintained. They are thus relieved of much responsibility. You will all remember how ill at ease you used to feel with premedication and anesthesia, but now you can rest assured that your patient is competently and comfortably taken care of. Physicians should see to it that hospitals are properly staffed with trained anesthetists. Another point that is not always taken into consideration is the fact that a good anesthetic agent reduces the time of convalescence. A patient who is able to command the services of a good surgeon gives no consideration to the matter of who is going to give him an anesthetic, and I think we, as surgeons, should protect our patients by seeing to it that the anesthetic is administered by a person who is trained in this field.

DR. SHERMAN SHAPIRO: I should like to ask Dr. Cullen his opinion of ethylene as an anesthetic, particularly in the performance of a mastoidectomy.

DR. GEORGE WOODRUFF: With reference to myringotomy, in my experience nitrogen monoxide has been satisfactory for use in the hospital, for both children and adults. But occasionally a patient cannot be taken to the hospital, and one does not like to use a local anesthetic, which is unsuitable for children and often results in an inadequate incision. I formerly used ethyl chloride, and, while I have had no unfavorable experiences, I am somewhat afraid of it, having heard so much about the danger. I think it is a problem to know what to use.

DR. GLENN GREENWOOD: I should like to ask what the routine medication would be for a patient weighing 150 pounds (68 Kg.), who is to have a diagnostic bronchoscopic examination.

DR. ROBERT GOOD: I agree with what Dr. Ballenger said about scopolamine. I had a patient in a small hospital who was given barbital two hours prior to

operation, then a hypodermic injection of scopolamine hydrobromide, morphine sulfate and atropine one-half hour before I performed a submucous resection. She was taken back to bed with the nose packed, and when I got back to her room she was not breathing. Had I not arrived when I did, she might have died.

Scopolamine should be used cautiously for old people. I had a patient aged 80 who was given scopolamine prior to injection for trifacial neuralgia, and hypostatic pneumonia developed. I think there is too much relaxation. Dr. Cullen mentioned that the drug should be used early enough so that the action will not be prolonged. I had hoped he would speak of the topical application of anesthetics on the mucous membrane. I wish some one would report a thorough analysis of the use of cocaine alone and in combination with epinephrine, with a study of the symptoms and a comparison of the results when the drugs are given to some patients sitting and to others in a recumbent position.

Some time ago I saw in one of the London hospitals a boy who was sitting waiting for the doctor. The nurse said that the nose had been packed with cocaine pads but that the doctor was late. I am opposed to putting cotton soaked with cocaine into the nose. It is not necessary to have the drug absorbed into the venous system. A few applications of cocaine and a solution of epinephrine hydrochloride made with a cotton applicator are sufficient, and excessive absorption is avoided.

DR. WALTER THEOBALD: Dr. Cullen represents a new science and a new art. It is becoming recognized that hospitals must have departments of anesthesia under the direction of qualified and experienced anesthetists. I should like to ask whether for simple operations, such as tonsillectomy and adenoidectomy in children, Dr. Cullen recommends or uses any premedication and what his choice of anesthetic would be for such operations.

DR. STUART C. CULLEN: Drs. Ballenger, Galloway and Good have mentioned the advisability of aiding premedication by assuring perfect preoperative quiet and rest for the patient. I concur heartily with them. The desired mental and metabolic state cannot be obtained merely by giving the right amounts of the right drugs at the right time.

In order that there be no misconception, I should like also to emphasize that one must not give large doses of premedicating drugs and then forget the patient. In many cases in which I think the premedication may cause sufficient narcosis to allow the airway to become obstructed, I give the drug intravenously after I have the patient under my supervision, so that I may take care of the airway and the oxygen supply.

With reference to the respiratory depressant effect of scopolamine, from Dr. Waters' clinical investigation and my clinical impression from the use of this agent in thousands of cases, I should say it is a respiratory stimulant; that is one of the principal reasons for using it in combination with morphine. In several thousand cases I have seen but one true reaction due to scopolamine.

In answer to Dr. Galloway's question, I find that there is a minimal depression of the cough reflex even with large doses of the combination of a barbiturate, morphine sulfate and scopolamine hydrobromide. I use that combination for patients with productive cough who are undergoing thoracoplastic procedures with anesthesia induced with nitrogen monoxide and find no appreciable diminution of the cough reflex.

The choice of anesthetics and technics for operations on the head and upper respiratory passages in which the endotherm is to be used is difficult. In order of preference, I use local or regional technics, nitrogen monoxide, pentothal sodium or chloroform. In each instance, however, a patent airway is established, which in many cases means the use of an endotracheal catheter.

Dr. Weiss inquired concerning the use of various agents in the presence of a high level of sulfanilamide in the blood. Only one agent is contraindicated, pentothal sodium, and that on the basis of experimental work by John Adriani, who demonstrated a marked lowering of the minimum lethal dose of pentothal sodium in rats given sulfanilamide.

The problem of anesthesia in minor surgical procedures carried out in home and office is difficult, and the ideal agent and technic are not yet apparent. My practice is to use whatever agent or technic seems best suited to the individual child and surgical procedure. In any event, care must be taken to avoid trouble, and preparation must be made to remedy trouble as it develops. Many unfortunate deaths have occurred in cases such as this because the anesthetist was unprepared for accidents.

My personal feeling about ethylene is that anything that can be done with ethylene can be done with nitrogen monoxide, and with less danger to the patient.

I am unable to answer Dr. Greenwood's question concerning the dosage of drugs for a man weighing 150 pounds (68 Kg.) who is to undergo a bronchoscopic procedure. It is essential that the patient be seen by the anesthetist and that all factors, particularly the age, be considered in estimating the dosage.

My usual anesthetic for tonsillectomy is ether, administered by the open drop method. I have minimal difficulty with it and see no reason for abandoning its use. I see no reason why children should not be premedicated with morphine.

In conclusion, I wish to compliment Dr. Lederer as a pioneer in anesthesia in Chicago. Although he disclaims being an anesthetist, he certainly must have been a good promoter.

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JEROME STRAUSS, M.D., *Vice President, presiding*

WALTER H. THEOBALD, M.D., *Secretary*

*Regular Monthly Meeting, Jan. 6, 1941*

**Carcinoma of the Esophagus: Endoscopic Experiences During the Past Year.** DR. E. W. HAGENS.

The report covers 8 cases of carcinoma of the esophagus encountered during the past year, and details of each are given. The value of endoscopic examination in such cases is stressed. It is highly desirable that diagnosis be made early. One of the abnormalities encountered is the border of firm, fixed edematous tissue lying just proximal to the lesion. This tissue is covered by epithelium of normal appearance and may be of such size that to bite through it with any instrument would be dangerous. The esophagus is usually narrowed by this tissue, so that it is practically impossible to see or get at the tumor. A small esophagoscope can be inserted in a large one and through the strictured area or inserted alone. This, however, narrows the field of vision and necessitates the use of a much smaller forceps for removal of a biopsy specimen. Also, the narrowness and rigidity of the area limit the mobility of the esophagoscope considerably. Hence, one is often faced with the choice of either making a diagnosis from the local findings or taking a chance of perforating by biting deeply into the tissue for a biopsy specimen. Taking the usual bite into the edematous tissue leads to a diagnosis negative for carcinoma.

When it is realized that an early diagnosis of carcinoma may make surgical treatment possible, whereas an indeterminate report may cause the thoracic surgeon to fear exploration and to wait until the lesion becomes too far advanced for surgical treatment, it is seen that the endoscopist carries considerable responsibility. It is sometimes advisable to take several specimens for biopsy, if possible from different sites. Many times reexamination is not possible, and the exact diagnosis rests on the single esophagoscopy and biopsy.

One of the difficulties of esophagoscopy is frequently lack of time for adequate preparation. Whenever possible, it is advisable for the endoscopist to take a complete history and to see and study the barium sulfate fluoroscopic pictures as well as to make a complete examination of the patient.

The points brought out by this study serve to emphasize that carcinoma of the esophagus should be borne in mind in all doubtful cases and should be carefully sought for. It is advantageous that the patient be cared for by a group of physicians who are accustomed to working together, as the members of such a group are more likely to arrive at an early and accurate diagnosis and to plan adequate treatment.

DISCUSSION

DR. JOHN R. LINDSAY: I enjoyed Dr. Hagens' paper very much. Knowing that he was going to present this subject, I brought along four sections of carcinoma of the esophagus, from cases in which I performed esophagoscopy and biopsy, after which the tumors were removed by Dr. William E. Adams. These sections show the full extent of the tumor as well as the mucosa and the full thickness of the esophageal wall above and below the tumor.

Two types of esophageal carcinoma are illustrated: the scirrhous and the medullary type. The slides of the scirrhous type demonstrate clearly the hypertrophy of the muscularis and mucosa as well as the hyperplasia of the epithelial layer, which extends well above the tumor, thereby producing obstruction well above the level of the tumor and creating the typical pale appearance which is observed on esophagoscopy. This illustrates why it is difficult to secure a biopsy specimen which goes deep enough to reach the true tumor tissue. The medullary type of tumor, on the other hand, is seen to produce outgrowths into the esophagus without hypertrophy of the esophageal wall above. This type is easily visualized, and tissues including tumor are easily obtained.

DR. PAUL HOLINGER: Dr. Hagens has stressed a number of interesting points. One of his most important statements, I believe, was that in the cases he presented no ill effects resulted from either the direct examination or the removal of tissue from the esophagus for biopsy. This emphasizes again the safety of a procedure which is indispensable for making a correct diagnosis.

I should like to stress another point in regard to carcinoma of the esophagus. This concerns the early diagnosis of the disease, prior to the appearance of roentgen evidence of its presence. Two factors are responsible for negative fluoroscopic and roentgenographic findings in the early stages of esophageal carcinoma. The first is that a carcinoma may be situated on the wall of the thoracic esophagus but not be large enough to cause a constant filling defect. The second is that a carcinoma may be situated high in the cervical part of the esophagus, at a point where the barium sulfate column is forced downward so rapidly by the strong muscles of the hypopharynx that a small irregular constant filling defect will be unnoticed. Thus, in a plea for early diagnosis of carcinoma of the esophagus I wish to stress the importance of esophagoscopy in spite of negative roentgen findings, if symptoms are suggestive of esophageal obstruction. Bronchoscopy is equally important in the diagnosis of bronchogenic carcinoma, of course, for frequently tumors of the bronchi manifest themselves clinically several months before they are demonstrable roentgenologically.

DR. W. E. ADAMS: It was a pleasure to hear Dr. Hagens' paper and the discussion on this subject, one in which I have been much interested. I think this group is going to play a significant part in advancing the treatment of these lesions.

To give you some idea of the magnitude of the problem, statistics gathered between 1925 and 1933 by Dormanns from 42 German institutions showed that among 124,827 patients with malignant disease of all kinds on whom autopsy was performed, death was due to carcinoma of the esophagus in 23,139. This includes about 8 per cent of all men over 20 years of age who died of malignant tumors. If one considers 150,000 deaths per annum in the United States due to malignant disease, one can get some idea of the number of deaths each year due to carcinoma of the esophagus.

On being asked to discuss the subject before the American College of Surgeons last October, I corresponded with a number of surgeons interested in carcinoma of the esophagus and gathered statistics relative to its surgical treatment. Of 67

carcinomas of the esophagus explored, 34 were successfully resected by twelve groups of physicians in the last two years. Prior to that time there had been only 29 successful resections, the first being done by Franz Torek in 1913. Of the 34 operations, 22 were of the Torek type and 12 were of the type in which the tumor is resected and the esophagus anastomosed with the stomach. Of the 34 patients who had successful resections, 20 were living at the time the statistics were gathered, some as long as four years after operation.

Early diagnosis is essential for successful surgical treatment. If it can be made within a relatively short time after the onset of symptoms, say within two or three months, about 40 per cent of the lesions will be operable; 60 per cent will have extended into adjacent structures or metastasized. A high percentage of patients having dysphagia seek the aid of a throat specialist; thus laryngologists play an important part in making early diagnoses by endoscopic examinations and biopsy. If the first biopsy reveals no evidence of carcinoma, a second should be made without delay. This is important, since carcinoma is the cause of dysphagia in a high percentage of cases.

Although definite progress has been made recently in this field, more may be expected when early diagnosis becomes more frequent.

DR. SAMUEL SALINGER: There are two points on which I should like to comment briefly. One is that the scirrhous type of carcinoma is not as rare as one might suppose, since Dr. Hagens has just shown several slides of tumors of this type. I can recall having seen only 2 over a long period of years, and at the time I was impressed with the fact that they were rather uncommon. In 1 case it was impossible to obtain a positive biopsy specimen, but at autopsy my associates and I found that the growth had formed an enormous heavy constricting ring about the lower end of the esophagus without breaking through the mucous membrane anywhere.

The other point is in relation to the use of surgical diathermy as a palliative measure in cases in which the lesion is inoperable. I employed diathermy in 2 cases and felt that by destroying the granulomatous masses which were present I lessened the amount of hemorrhage and also kept the passage open for feeding. Naturally there is some danger of perforation if the treatment is too vigorously applied, and perhaps this is the reason it is not used more frequently. In another instance the diathermy was applied to the lower end of the esophagus by way of a gastrostomy. I should like to know whether this type of procedure was ever used in any of Dr. Hagens' cases.

DR. E. W. HAGENS: In reply to Dr. Salinger, I have contemplated using diathermy for my patient.

**Factors Influencing Hearing Improvement After Fenestration for Otosclerosis.** GEORGE E. SHAMBAUGH JR.

The best results reported from the fenestration operation have followed the use of the one stage technic of Lempert. The original technic, however, gave results that still left much to be desired. According to Lempert's first report, 19 of 23 patients operated on experienced improvement in hearing, but a report two years later showed that 9 of the 19 subsequently submitted to reoperation because they had lost the improvement.

From July 1938 to January 1940 I employed the operation for 13 patients, 2 of whom had the operation on both ears, making a total of 15 fenestrations in a year and a half. In each case Lempert's technic was followed correctly, and yet the final results were disappointing. Only 3 fenestrae remained open, with a lasting and significant improvement in hearing.

In January 1940 one fenestra that had closed a year before was revised. When the skin was elevated from the horizontal semicircular canal, the fistula was found to be completely occluded by a plug of new bone with a granular appearance, as though formed from bone dust. Apparently the removal of bone dust by cotton applicators dipped in a saline solution had not prevented some of the dust

produced by the use of the finishing burr from falling into the fistula. A simple irrigating apparatus was then devised, to maintain a constant flow of warm sterile physiologic solution of sodium chloride across the horizontal canal during the creation of the fenestra. Not only was every particle of bone dust washed away, but the field was kept perfectly clean and free from blood. This improvement in technic has now been used in the creation of 40 new fenestrae and in 10 revisions, and in none has complete bony closure of the fenestra occurred.

In 7 out of 40 of the operations for the creation of a new fenestra and in 2 of 10 revisions the final result was unsatisfactory. In 7 of the 9 unsatisfactory operations the poor results were due to generalized or localized serous labyrinthitis, possibly caused by trauma, by infection or by blood or serum from the under surface of the skin flap. To overcome or minimize postoperative serous labyrinthitis, two further modifications of technic have been devised. Sulfanilamide or sulfathiazole (2-[paraaminobenzenesulfonamido]-thiazole) is used in the wound, and the operation is performed under a binocular dissecting microscope. The value of this more meticulous technic will no doubt become evident.

From the results observed in 50 patients, 4 of whom had both ears operated on and 11 of whom had revisions, I believe not only that the refinements of technic have improved the proportion of successful operations but that the lasting gain in hearing has increased greatly. There have been no deaths, no serious complications and no case in which the hearing in the ear which was operated on has been made worse.

DISCUSSION

DR. WALTER THEOBALD: I should like to ask Dr. Shambaugh whether he has been able to cover the region of fenestration with the tympanic membranous flap. The distance is so great that I wonder whether there has been some retraction from the area of fenestration. I am reminded of the radical operation in which an amniotic flap was used. That might be a thought, if the tympanic membranous flap is not sufficient.

DR. GLENN GREENWOOD: I wonder whether some of the success attributed to the removal of bone dust might accrue from the fact that the heat due to friction of the burr is somewhat more controlled. I wish to commend Dr. Shambaugh for adapting to this field the excellent irrigating apparatus described.

DR. GEORGE E. SHAMBAUGH JR.: In answer to Dr. Theobald, the tympanomeatal flap is always long enough to reach well up over the fistula. However, I am certain that Shrapnell's membrane does not reach the fistula except in unusual cases. I spend a good deal of time with the binocular magnifying loupe, picking off little fragments of bone from the part of the skin flap which will cover the region of the fistula. The presence of these fragments means to me that that part of the membrane is not Shrapnell's but is from the bony canal wall. However, in each case the skin is long enough to cover the fistula without trouble.

In answer to Dr. Greenwood, concerning the heat generated by the burr: Why the finishing burr seems to inhibit the regeneration of bone has not yet been answered. Certainly with irrigation no heat is generated, and this should help to protect the membranous labyrinth.

**Orbital Cellulitis.** L. J. WALLNER.

Acute sinusitis accounts for 70 to 80 per cent of all cases of orbital cellulitis, the ethmoid sinuses being more commonly involved in infants and the frontal in adults. The acute sinusitis associated with scarlet fever and that following swimming are especially likely to give rise to orbital disease.

Several types of pathologic condition have been described as the cause of the symptoms of chemosis, proptosis, fixation, edema and redness of the lids. The same symptoms are present in thrombosis of the cavernous sinus, due to venous obstruction. It is suggested that venous stasis is the prominent factor in such orbital disease, whether due to a subperiosteal abscess, true cellulitis of the orbit

or thrombophlebitis. Some experiments were performed on dogs, showing the effect of pressure on the ophthalmic veins, which caused proptosis, chemosis and edema of the lids.

Ten cases of orbital cellulitis are listed briefly; in 2 the condition followed scarlet fever and in 4 it followed swimming. There were 2 deaths, and the postmortem findings are described.

Conservative therapeutic measures are advised, the local use of astringents in the nose, hot applications, roentgen therapy and chemotherapy.

DISCUSSION

DR. ALFRED LEWY: I have encountered orbital cellulitis following inflammation of the antrum in 4 adults. In children the condition is usually associated with ethmoid inflammation, as Dr. Wallner said. I have encountered only 2 children in whom it was associated with inflammation of other sinuses. In one of these, before the days of convalescent serum and sulfathiazole, the orbital cellulitis was associated with scarlet fever. I recommended operation, which was not done, and the child recovered. I have seen a number of patients recover under more conservative treatment. Two of these were treated by irrigation of the maxillary sinus. In one, I believe, there was a beginning osteomyelitis of the superior maxilla.

DR. HOWARD C. BALLENGER: I believe there is no question that in a few cases orbital cellulitis is due to infection of the maxillary sinus. However, in my experience infection of the ethmoid has been a much greater factor.

Several years ago I went over the records of all cases of orbital cellulitis and orbital abscess at the Children's Memorial Hospital. In about 10 per cent of these cases some form of surgical drainage was necessary. In the other 90 per cent the inflammation subsided without surgical intervention. Recently I treated a boy 12 years of age who had an orbital cellulitis without any evident orbital abscess. He recovered after treatment with hot compresses and local medication but has been left with limited extraocular motion of the involved eye. It is possible that if some form of surgical drainage had been instituted the loss of ocular motion might have been avoided.

**The Pathology of Benign Polyps of the Larynx.** S. A. FRIEDBERG.

DISCUSSION

DR. WALTER H. SEGAL: One question is, why do polyps develop just on or near the edge of the vocal cord? Polyps develop in the subepithelial space, which surrounds the vocal cord and is limited in all directions. It extends from the anterior commissure to the processus vocalis and above and below about to the border where the stratified epithelium goes into cylindric epithelium. To demonstrate this space, Hajek injected it with a stained mass, which showed that the subepithelial space is limited outside by the elastic membrane or ligamentum vocale. Anteriorly and posteriorly the elastic membrane shades into the cartilage. Above and below, the membrana propria takes on a different texture. There are many mucous glands in it, which are surrounded by elastic fibers, and it is therefore dense and resistant. This is the outer border of the space; the medial border is formed by the stratified epithelium, which reaches above and below about 1.5 or 2 mm. from the free edge of the vocal cord. It consists of ten to twenty layers of stratified epithelium. At the edge and on the upper surface near the edge it is thin and there are only two or three layers. This thin epithelium forms a point of less resistance, and if there is congestion with secondary edema, the thin epithelium at the medial border of the Reinke space gives way. The elastic membrane, interlaced with muscle fibers, offers too much resistance to be affected by the pressure.

The second point is the vascularization of the vocal cord. The arteries are scarce, but the veins are numerous and large and form three separate nets, lying

one above the other. In the vocal cords this superficial net forms long stretched meshes. Through increased and prolonged pressure these thin and numerous veins can easily become compressed, and congestion may develop in this space.

The last point deals with the question of why polyps usually develop at the border of the anterior and middle third of the vocal cord. The cords work in somewhat the same manner as the lips of a reed pipe, which is blown on from below. They move from the middle to the side and back again and thus nodes and antinodes develop. The nodes are points which are resting, while the bordering parts are in motion. Gutzmann has shown that at the point where polyps develop there is a sort of vibrational node. The vocal cords do not come in contact at this point, while they do so elsewhere. It has also been shown that they are rather concave here. One might speculate from these facts that at the point where the cords are at rest and are concave, blood could accumulate and stasis develop, with consequent edema, thrombosis and hyalinization. Polyps are therefore most frequent in man and particularly in those who habitually overstrain their voices, such as singers. Acutely developing polyps are found at the same place as those which are chronic. Often these polyps rupture and heal without intervention. It may be said, then, that anatomic and functional disorders work together to produce polyps. Changes of an inflammatory nature are secondary and disappear when the polyps have been removed and the functional disturbances have been eliminated.

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## COLLEGE OF PHYSICIANS OF PHILADELPHIA, SECTION ON OTOLARYNGOLOGY

KARL M. HOUSER, M.D., *President*

GEORGE L. WHELAN, M.D., *Recorder*

*Regular Monthly Meeting, Jan. 15, 1941*

**Frontal Sinusitis.** DR. J. MACKENZIE BROWN, Los Angeles.

(A short review of the development of the frontal sinus from fetal life to the age of 20 years, when it reaches its full development, is followed by a description of the sinus as seen in children and adults, with emphasis on its frequent asymmetry and anatomic variations as well as on the different anatomic configurations of the nasofrontal duct, which depend on the site of origin of the anlage of the frontal sinus and influence the clinical accessibility and efficiency of the duct. When continuity in the nasofrontal connection is lacking, the thin bony roof of the ethmoid labyrinth is easily penetrated during sounding of the sinus. Various anomalies in the frontal sinus are mentioned.

The importance of a knowledge of diploic distribution in the prevention and management of osteomyelitis is stressed, as this disease cannot develop in compact bone. Infection of compact bone results in osteitis, which is self limiting, whereas osteomyelitis is usually a spreading disease. Among the highly diploic areas are mentioned the bone of the external or inferolateral recess or angle of the frontal sinus and the region adjacent to the superior sulci of the two frontal sinuses, where the anterior and posterior plates fuse, which is in contact with the cavity of the sinus as well as with the dura. The anatomy of the diploic veins is described, and attention is drawn to the fact that thrombophlebitis of these veins may precede osteomyelitis, which spreads along their course.

Staphylococcus is encountered most frequently as the responsible organism in both acute and chronic frontal sinusitis, although anaerobic nonhemolytic streptococci have been isolated in some cases of osteomyelitis. In a series of 18 cases of acute frontal sinusitis, growths obtained from cultures from trephine openings

included Staphylococcus aureus, Staphylococcus aureus haemolyticus, Staphylococcus albus, Streptococcus (gamma, beta and virus types) and Diplococus pneumoniae.

The chief etiologic factors in acute frontal sinusitis are infections of the upper respiratory tract, swimming and trauma. The dangerous aspect of the pathologic process is that the acute exudation of purulent matter occurs within a closed bony cavity and that the channel of egress may become closed or partially closed by intense edema of its mucosa. Any increase in pressure within this bony cavity can easily be transmitted to the diploe, the diploic veins, the meninges and the brain. Unless intrasinal pressure is relieved, progression of inflammation must occur, and retrograde thrombophlebitis with consequent osteitis or osteomyelitis will result. The mortality in osteomyelitis of the frontal bone, even of the so-called nonspreading variety, is high.

In acute frontal sinusitis, transillumination may or may not reveal increased density on the affected side, and roentgenograms do not always show the opacity. The difficulty of excluding ethmoiditis in the differential diagnosis is mentioned.

The complications discussed include meningitis, periostitis and subperiosteal abscess, osteomyelitis, thrombosis of the longitudinal sinus, extradural abscess and intracerebral abscess. The diagnosis of abscess of the frontal lobe is one of the most difficult in neurologic practice.

Chronic frontal sinusitis is usually due to repeated attacks of the acute process, although it may develop after a single attack when anatomic obstruction prevents proper drainage and ventilation. Allergy may also play a part. After a short paragraph on the pathologic manifestations and diagnosis of chronic frontal sinusitis, the treatment of the acute and chronic forms of the disease is discussed.

The conclusion is that for acute frontal sinusitis in swimmers who do not obtain prompt relief by shrinkage external trephining should be done as an emergency measure. This intervention is also recommended for subperiosteal abscess below the eyebrow. When signs of meningitis or extradural abscess have developed, removal of the posterior plate is indicated, and if spreading osteomyelitis is present, prompt radical removal of the diseased bone is imperative. Intranasal surgical treatment for acute frontal sinusitis is to be condemned.

For chronic frontal sinusitis a progressive scheme of treatment is outlined, including systemic treatment, with allergic, endocrine and dietary management, submucous resection for septal obstruction, removal of diseased tonsils and adenoids, correction of suppurative disease of the other paranasal sinues and preliminary intranasal ethmoidectomy (Mosher). If these measures prove unsuccessful, external surgical procedures may be required to cure fistula and symptoms of retention. The Lynch or the Sewall procedure is adequate in most cases, but the Killian obliterative operation is necessary for disease of the external table and for the treatment of multilocular sinuses with small anterior-posterior diameter.)

DISCUSSION

Dr. George M. Coates: Rather than review the subject matter so ably presented by Dr. Brown, I should like to discuss briefly a few forms of frontal sinus disease that could not be discussed in detail by Dr. Brown on account of time limitations. Several of these are comparatively rare conditions, such as cholesteatoma of the frontal sinus, of which few cases have been reported. Although it is possible that cholesteatoma of the frontal sinus results from epidermal extension inward, as is so frequently the case with the cholesteatomatous mastoid, present opinion seems to favor the theory that embryonal rests are the productive factor. I have seen but 1 case of cholesteatoma of the frontal sinus, and the cause is doubtful, for there was a history of early traumatism and possible fistulization years before. Aside from the typical cholesteatomatous mass, the pathologic conditions observed at operation were absorption of the orbital wall of the frontal sinus, the exterior table and the interior table, with orbital abscesses and proptosis. A radical operation with obliteration of the frontal sinus established a cure, which has been maintained for about five years.

Another type of pathologic condition due to long-continued infection is a filling-up of the frontal sinus by bony proliferation, usually from the anterior wall. This is to be differentiated from a true osteoma. It is characterized chiefly by headache and is diagnosed by roentgen examination. With Dr. Samuel R. Skillern, I have encountered over a dozen cases of this condition and have noted that complete and radical removal of the soft spongy bone down to the compact bone of the sinal walls is necessary for relief from symptoms. In a number of cases the sinus had been almost totally obliterated, only a chink remaining between the new growth and the internal table. Dr. Skillern and I have usually referred to this condition as osteogenesis of the frontal sinus.

In regard to osteomyelitis of the frontal bone, the bête noire of rhinologists for many years, the technic of radical extirpation has been adopted in my hospital service. We follow Mosher's procedure of beginning the bony resection from 1½ inches (3.8 cm.) to 2 inches (5 cm.) beyond the upper limit of edema. Our mortality record has been good, but I have observed that in many cases, especially the ones in which the osteomyelitis can be attributed to swimming, the condition is already complicated by extradural abscess or true frontal lobe abscess by the time the diagnosis has been made and the operation performed. I believe, therefore, that it is unwise, particularly in cases of osteomyelitis due to swimming, to wait on the chance that the inflammation may be of the nonprogressive type in which localized sequestration may occur. I have rarely seen the latter condition.

In acute frontal sinusitis, when infection or destruction of the bony walls of the sinus has already occurred, I think it is usually wise to remove all softened bone. This is generally in the anterior table, where osteomyelitis may be already established in the diploic bone, and I therefore prefer an operation through the anterior table rather than through the floor of the sinus, as advocated by Dr. Brown, according to the technic of Lynch, Sewall and others. Theoretically, the floor of the sinus does not contain diploic bone; therefore, surgical intervention in this region should not cause osteomyelitis. In one of the few cases, however, in which this approach was used, osteomyelitis developed, which later necessitated removal of the anterior table by a supraorbital approach. Of course, this involvement may not have been due to surgical intervention, and there is no question that the approach through the floor of the sinus causes better cosmetic results. If simple trephination is to be used for drainage purposes, I feel sure that Dr. Brown's technic is better.

Dr. James A. Babbitt: It is a great honor to us to have here the presidents of the American Laryngological, Rhinological and Otological Society, Inc., and the American Otological Society.

Dr. Brown in selecting the topic frontal sinusitis has elected to present to us a subject on which he has much of information and suggestion. The characteristics of the development of the frontal sinus, with its septums and its compact and diploic bone areas with their tendencies to osteitis and osteomyelitis, respectively, and infection—the paths of danger in the diploic veins, the organisms which make trouble and other related matters—have been presented in a direct and illuminating way.

He has dilated on the bad effects of swimming, carrying out the splendid work of Marshall Taylor; he has reviewed the symptoms in acute and chronic sinus conditions and treatment for each condition, with the complications, meningeal and otherwise. I feel that the members of this society have been presented a new, clearcut textbook on the whole matter.

Dr. Coates has presented a most valuable discussion of Dr. Brown's paper, with practical comments and suggestions in regard to the areas of compact bone around an involved sinus, the interesting vagaries of cholesteatoma and the debatable progressive character of osteomyelitis.

Dr. Samuel R. Skillern: This is a subject about which I could talk for several hours. My experience has been that no two sinuses are exactly alike. The operative procedure must suit the particular case. Certainly the anterior, and also,

if diseased, the posterior, ethmoid cells should be removed at the time of operation. Threatened intraorbital or intracranial complications call for immediate action.

Dr. Warren B. Davis: The danger in probing the frontal sinus lies in the possibility that one may not be properly oriented and may introduce the instrument medially through the cribriform area instead of laterally through the anterior end of the infundibulum or through the ostium frontale contiguous to this area.

The process of pneumatization of the frontal sinus gradually extends from that portion of the anterior ethmoid area toward and into the inferior portion of the frontal bone. The sinus, surrounded as it is by a thin lamina of compact bone, then advances toward the ascending portion of the frontal bone, advancing as the cancellous bone is resorbed. In an average person this rate of resorption is such that the sinus begins its ascent into the vertical portion of the bone during the second year of life and in the third year is 3.8 mm. above the level of the nasion. As the sinus frontalis advances into the vertical portion of the bone, its posterior wall is always thin and is composed almost entirely of compact bone, while the anterior wall, as found in different specimens, varies greatly in thickness and usually contains a considerable amount of diploe.

Dr. Karl M. Houser: The members of this society are indeed grateful to Dr. Brown for his excellent and most inclusive paper on frontal sinusitis. Hearing it, I have gained more respect for the Philadelphia climate. Dr. Brown's reference to 15 cases leads me to believe that the Philadelphia climate is not too bad if such a number of cases is encountered over a given period in sunny California.

Dr. George L. Whelan: The members of this society are indeed honored this evening in having Dr. J. Mackenzie Brown, president of the American Laryngological, Rhinological and Otological Society, Inc.; Dr. George M. Coates, president of the American Otological Society, and Dr. James A. Babbitt, president-elect of the American Laryngological, Rhinological and Otological Society, Inc.

Dr. J. Mackenzie Brown: I wish to thank the members of the society for the honor of reading this paper before you this evening. If I had anticipated Dr. Houser's remarks about the climate, I should have said that the patients whose cases were reported had previously lived in Philadelphia. However, this is not so. Our hospital service in Los Angeles is a large one, which accounts for the numerous cases encountered.

# Directory of Otolaryngologic Societies *

## NATIONAL

### American Medical Association, Scientific Assembly, Section on Laryngology, Otology and Rhinology

Chairman: Dr. LeRoy A. Schall, 243 Charles St., Boston.
Secretary: Dr. Louis H. Clerf, 1530 Locust St., Philadelphia.
Place: Cleveland. Time: June 2-6, 1941.

### American Academy of Ophthalmology and Otolaryngology

President: Dr. Frank Brawley, 30 N. Michigan Ave., Chicago.
President-Elect: Dr. Frank R. Spencer, Physicians' Bldg., Boulder, Colo.
Executive Secretary: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.
Place: Chicago. Time: Oct. 19-24, 1941.

### American Broncho-Esophagological Association

President: Dr. Gabriel Tucker, 250 S. 18th St., Philadelphia.
Secretary: Dr. Paul Holinger, 1150 N. State St., Chicago.
Place: Cleveland. Time: June 3, 1941.

### American Laryngological Association

President: Dr. Gordon Berry, 36 Pleasant St., Worcester, Mass.
Secretary: Dr. Charles J. Imperatori, 108 E. 38th St., New York.
Place: Atlantic City, N. J. Time: May 28-30, 1941.

### American Laryngological, Rhinological and Otological Society, Inc.

President: Dr. J. Mackenzie Brown, 1136 W. 6th St., Los Angeles.
President-Elect: Dr. James A. Babbitt, 1912 Spruce St., Philadelphia.
Secretary: Dr. C. Stewart Nash, 708 Medical Arts Bldg., Rochester, N. Y.
Place: Ambassador Hotel, Los Angeles. Time: June 16-18, 1941.

*SECTIONS:*

Eastern.—Chairman: Dr. N. S. Weinberger, Robert Packer Hosp., Sayre, Pa.

Southern.—Chairman: Dr. William G. Kennon, Doctors Bldg., Nashville, Tenn.

Middle.—Chairman: Dr. Walter H. Theobald, 307 N. Michigan Ave., Chicago.

Western.—Chairman: Dr. Robert C. Martin, 384 Post St., San Francisco.

### American Otological Society

President: Dr. George M. Coates, 1721 Pine St., Philadelphia.
Secretary: Dr. Isidore Friesner, 36 E. 73d St., New York.
Place: Atlantic City, N. J. Time: May 26-27, 1941.

* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.